PATHS TOWARDS SUCCESS AND FAILURE IN PHYSICS AT G.C.E. ADVANCED LEVEL : A LONGITUDINAL STUDY OF PUPILS' ATTITUDES

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CONTENTS

TABLES AND FIGURES page

TABLES

page

FIGURES

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ABSTRACT

In a longitudinal study of pupils' attitudes towards physics in the fifth- and sixth-forms, it has been found that meaningful clusters of pupils exist at both levels. The criterion outcomes of physics attainment and enjoyment can be characteristically 'predicted' for each stereotype grouping. A planned, 'logical' method of teaching, which encourages discussion and speculation supported by visual media, permits attainment and attitudes to be maximised for two-thirds of the sixth-form groups. A similar approach in the fifth-form, which also provides for teaching-for-understanding, is recommended for five of the seven pupil-types identified. Practical teaching strategies are outlined for dealing with physics classes comprising a range of pupil-types.

From an analysis of teachers' perceptions of effective science teaching behaviour, seven teacher stereotypes have emerged.

A group of 'optimum outcome' classes has been identified in the fifth-form. These classes are taught by 'model teachers', who recognise the nature of science and teach by experiment, based on a coherent theory of learning.

Generally, physics is rated the most difficult of the common academic subjects in the fifth-form. This rating is little different even for the A-level physics choosers. The latter tend to select the subject primarily for career reasons. Physics is rejected at A-level because of its difficulty and a lack of interest in the O-level course.

Subject enjoyment deteriorates for boys during the sixth-form course, but remains stable for the girls. Course outcomes vary according to G.C.E. A-level examining board.

Attainment and enjoyment generally show a significant association, although this disappears for girls in the upper sixth-form.

CHAPTER 1

INTRODUCTION

1.1. EXPANDING TECHNOLOGICAL EDUCATION - THE NINETEEN SIXTIES

The nineteen-sixties in the United Kingdom saw a general expansion of educational facilities, not the least at secondary and tertiary levels. New universities were established. The economic and political climate allowed technological education, particularly, its head. Colleges of advanced technology became technological universities, while other colleges of technology began to develop into the vocationally oriented polytechnics (Robinson, 1968). At the secondary level, the comprehensive system was steadily expanding (Pedley, 1963) with growing sixth-forms attracting students with increasingly diverse needs (H.M.A., 1968; Schools Council, 1973).

1.2. THE 'SWING FROM SCIENCE'

Educational facilities for science and technology were being improved, but students in these disciplines appeared to be slow to appreciate the opportunities available. So great was the concern about the relative unpopularity of science and technology in higher education, that the Government's Council for Scientific Policy established in 1965 the Dainton Enquiry to investigate the factors affecting the flow of science candidates into tertiary education. The report of this Enquiry (the Dainton Report, 1968) drew attention to the following facts:

1 entries in science subjects at the G.C.E. O-level stage had been increasing steadily

not only in absolute terms but also as a proportion of the age group,

2 the number of students entering the sixth-form was increasing rapidly, and

3 the proportion of first year A-level students taking science subjects had dropped sharply over a period of five years, and this proportional fall had been accompanied by a decrease in the absolute number of science students.

In an attempt to reverse these trends, termed the 'sixth-form swing away from science' by Rosenhead (1968), the Report's recommendations included:

1 premature specialisation in the middle years of secondary education should be reduced so that more pupils could study science for a longer time,

2 all sixth-form students should study a broad span of subjects, including mathematics,

3 science curricula and teaching should be made more modern and humane, and

4 the majority of young pupils in secondary schools should come into contact with good science teaching.

An education conference was called by the Association for Science Education (A.S.E.) to discuss the implications of the Dainton Report (Newall, 1969). Suggestions for action included reducing the content and conceptual levels of A-level science syllabuses, modernising courses and a close look at teacher quality.

It is clear from the Dainton Report and the discussion which followed that a deterioration in attitudes towards the study of science was being hypothesised as a contributory factor to the swing from science. Forrest et al. (1970) showed that the academic aptitude of A-level science candidates was higher than that for other student groups. This evidence encouraged Duckworth (1972) to suggest that the swing phenomenon is illusory, being a movement away from high aptitude, A-level subjects by the relatively recent, lower ability sixth-form arrivals. The students in the latter category would not be expected to be serious candidates for the classical mathematics-physics-chemistry subject grouping, so it would be unfair to use their existence as evidence of a swing from science. Duckworth's hypothesis, a consequence of a survey of pupils' attitudes, articulated the feeling of a 'significant proportion' of science teachers at the A.S.E. conference referred to earlier who denied that any science swing existed.

Duckworth's research is of some significance, demonstrating the perceived difficulty of the physical sciences in secondary school so clearly and their relative unattractiveness, even to able pupils. The statistical reality of the 'swing' was, of course, not in dispute. What was uncertain was the <u>meaning</u> of the swing. Pell (1975, 1977) attempted to clarify the swing in particular subjects by comparing A-level entrants with O-level passes exactly two years before - two years is the normal length of the A-level course. Figure 1.2.1 shows sharply the swing over a decade and half. Pell's accompanying pupil-attitude survey identified four factors, which in combination, were felt to be responsible for the statistical swing:

1 the poor image of O-level physics,

2 the considerable difficulty of the O-level subject,

3 unattractive A-level physics teaching methods,

and 4 the expansion of the range of available A-level subjects.

Pell hypothesised that in attitudinal terms little had probably altered over the years, and for many pupils physics was a rather uninspiring subject. Now, with the expansion of sixth-form education, and choice pupils of this type were able to 'swing against' the subject after O-level.

1.3 THE MIXED IMPACT OF THE NEW SCIENCE CURRICULA

The attitude surveys of Duckworth and Pell were just two of a number in the field of science education in the United Kingdom which were performed to explore the nature of science education, especially at secondary level. There appeared to be an uneasy feeling abroad that, despite economic support and science curriculum reform, the effectiveness of science education was showing little change (Ormerod with Duckworth, 1975). This feeling

Fig. 1.2.1 THE VARIATION IN THE PERCENTAGE OF QUALIFIED O-LEVEL STUDENTS ENTERING THE A-LEVEL PHYSICS EXAMINATION, ACCORDING TO SEX

[Source: tables 28 and 29, D.E.S., 1981 and earlier years] found expression at government level, some eight years after the publication of the Dainton Report, in a Memorandum to the Prime Minister from the Department of Education and Science (D.E.S., 1976) which referred to:

> "...grounds for dissatisfaction in the lowly position of the physical sciences... 13-14 year-old pupils opting in insufficient numbers for scientific and technological subjects ... schools need to encourage more pupils to study science."

A few years before the deliberations of the Dainton Enquiry, the Association for Science Education had joined with the Nuffield Foundation to embark upon a curriculum development programme to provide modern courses to O- and A-level in the sciences (Keohane, 1972). It was hoped that these new courses would help reverse the science 'swing' (Ashton and Meridith, 1969). Yet, Ahlgren and Walberg (1973) were to show that modernising an advanced physics course does not, by itself, improve students attitudes towards physics, while Gardner (1974) has suggested that improved science teacher education is likely to be more worthwhile than the introduction of new science curricula.

A review of Nuffield O-level courses in the separate sciences by Meyer (1970), admittedly with the 'trials' materials, showed that the new curricula had only a limited effect. In particular, Nuffield physics was much less attractive to boys than was the traditional physics course. In Meyer's opinion, the Nuffield curriculum developers had moved too far towards a problem-centred approach to science teaching and had defined objectives too narrowly in terms of this one approach, Meyer went on to criticise the authors as being educationally naive. Layton's remarks that the curriculum reformers might have over-reacted to the prevailing authoritarian teaching of science may be taken in support of Meyer's view (Layton, 1973).

A later evaluation conducted by the National Foundation for Educational Research (Choppin, 1974) revealed that pupils following Nuffield biology or chemistry courses showed greater increases in achievement than those following the corresponding traditional courses. Attitudes towards the Nuffield biology and chemistry courses were also superior. However, in physics, Choppin confirmed Meyer's attitudinal results and also found no overall achievement differences.

A third study of the effect of Nuffield chemistry alone (Kempa and Dubé, 1974) is of interest for two reasons.Firstly, the researchers used Meyer's original scales but with samples of pupils five years later. Attitude differences were found always to favour traditional chemistry courses. Their explanation for this was that the Nuffield population had become less select after the early trials and that the pupils of lower ability preferred the more factually based traditional courses. Secondly, the attitudinal results found by Kempa and Dubé in the chemistry evaluation are opposite to those found by Choppin, but as the former have pointed out, attitude changes seem to depend upon ability and unless this variable is controlled for ambiguous results are inevitable.

It appears from these Nuffield O-level evaluations, that in two of the sciences, biology and chemistry, marginal improvements in the qualty of science education could have resulted, but that in physics Meyer's criticism could be justified and the curriculum exercise has proved unsuccessful. It might be argued that 'marginal' improvement is no real improvement (pace the D.E.S. Memorandum) unless some precise criterion is established.

Further, the lack of a sound curriculum model and rather imprecise course objectives has made impartial evaluation of the early Nuffield courses difficult. Even when a consensus view emerged, for instance, Meyer's and Choppin's findings on the nature of the physics course,it was not unusual for a quite different opinion to be presented by those using different criteria. This point is well illustrated by the subjective review of the physics course by Rogers (1975),who came to a very different conclusion to Meyer and Choppin mainly because he used criteria of evaluation that are arguably imprecise and lack the systematic consistency of the independent researchers.

Tawney (1976)has referred to the weak nature of evaluation in curriculum projects in the U.K. He gives examples, including instances from his own experience as an evaluator, where findings are ignored or not published if views contrary to the project's overall aims are expressed. He points out that Meyer's evaluation, of some significance to U.K. teachers, was not, in the event, published in the U.K. To Tawney, a major failing in the development of the new science curricula was the inability to use the techniques of curriculum development that had been developed during the previous decade overseas, notably in the United States.

Despite the best of intentions, attempts to improve the quality of science education in the late nineteen-sixties and early nineteen-seventies did not meet with unqualified success. Biology was a possible exception (Ormerod with Duckworth). This subject had always attracted girls and showed a much smaller 'swing' than the physical sciences. The relative disenchantment with the changes in the physical sciences, and indeed in the continuing traditional courses, was echoed by Gaskell (1975) when he expressed concern over the flow of students into careers in chemistry, and was almost certainly uppermost in the minds of Ormerod and Duckworth (1975) when they wrote:

> "Hence, though the Nuffield schemes were introduced in part to increase the pool of pupils with a knowledge of physical science, they appear to have been unsuccessful in this aim. In addition, because of the neglect of the affective domain and the failure to monitor the effects of curriculum development, the dysfunction between the reform of the curriculum and the needs of the pupils was not identified. By their opting out of physical science, our young people have been telling us a great deal about our curricula, our schools and our society."
>
> (op.cit. pp.111-2)

1.4. THE PHYSICS ' SWING' IN THE UNITED STATES OF AMERICA

A swing from science, or more particularly a swing from physics, was clearly identified in the U.S.A. a decade earlier than in the U.K. Only a very small proportion of senior high school students were electing to study physics (Friskopp, 1972), which led directly to the setting up of the Physical Science Study Committee (P.S.S.C.) to oversee the development of a new physics course for the schools.

P.S.S.C. physics was to be a process-centred rather than a content-centred course with emphasis on experimental work and the scientific method. Friskopp writes:

> "The central part of the course is the textbook for the students. According to the basic philosophy the text is more wordy and mathematical formulae occur more rarely than in most physics textbooks."
> (op.cit. p310)

Other innovations included integral teaching films on topics that teachers would find difficulty in demonstrating in the laboratory and a series of background readers, the Science Study Series (Heinemann, 1961).

Parallel with this development in physics education, Bloom et al. (1956) were analysing the psychological outcomes of learning. Dividing these outcomes into three main classes:

(i) the cognitive domain, concerned with the recall of knowledge and the development of intellectual skills;

(ii) the affective domain, concerned with emotional behaviour such as interests and attitudes, and

(iii) the psychomotor domain, concerned with manipulative skills.

Bloom et al. were able to propose a detailed hierarchical structure of increasing complexity in cognitive learning. Subsequently, Krathwohl et al. (1964) and Simpson (1966) have proposed corresponding learning hierarchics in the affective and psychomotor domains, respectively. Tyler (1949) had earlier suggested a linear model of the curriculum comprising:

(i) educational purposes or aims,

(ii) learning experiences used to achieve these aims,

(iii) organisation of learning experiences, and

(iv) evaluation of the achievement of the aims.

Bloom's hierarchy of behavioural outcomes allowed stage (i) of the curriculum model to be explicitly stated in terms of specific outcomes or objectives. Stage (iv) then permitted the effectiveness of the learning sequence to be assessed by considering each precise objective in turn.

The P.S.S.C. physics course apparently drew only slightly from the emerging theory of the curriculum but, even so, its innovatory nature made it attractive to a number of European countries (Friskopp), to New Zealand (Heath, 1972) and later Australia (Gardner, 1974).

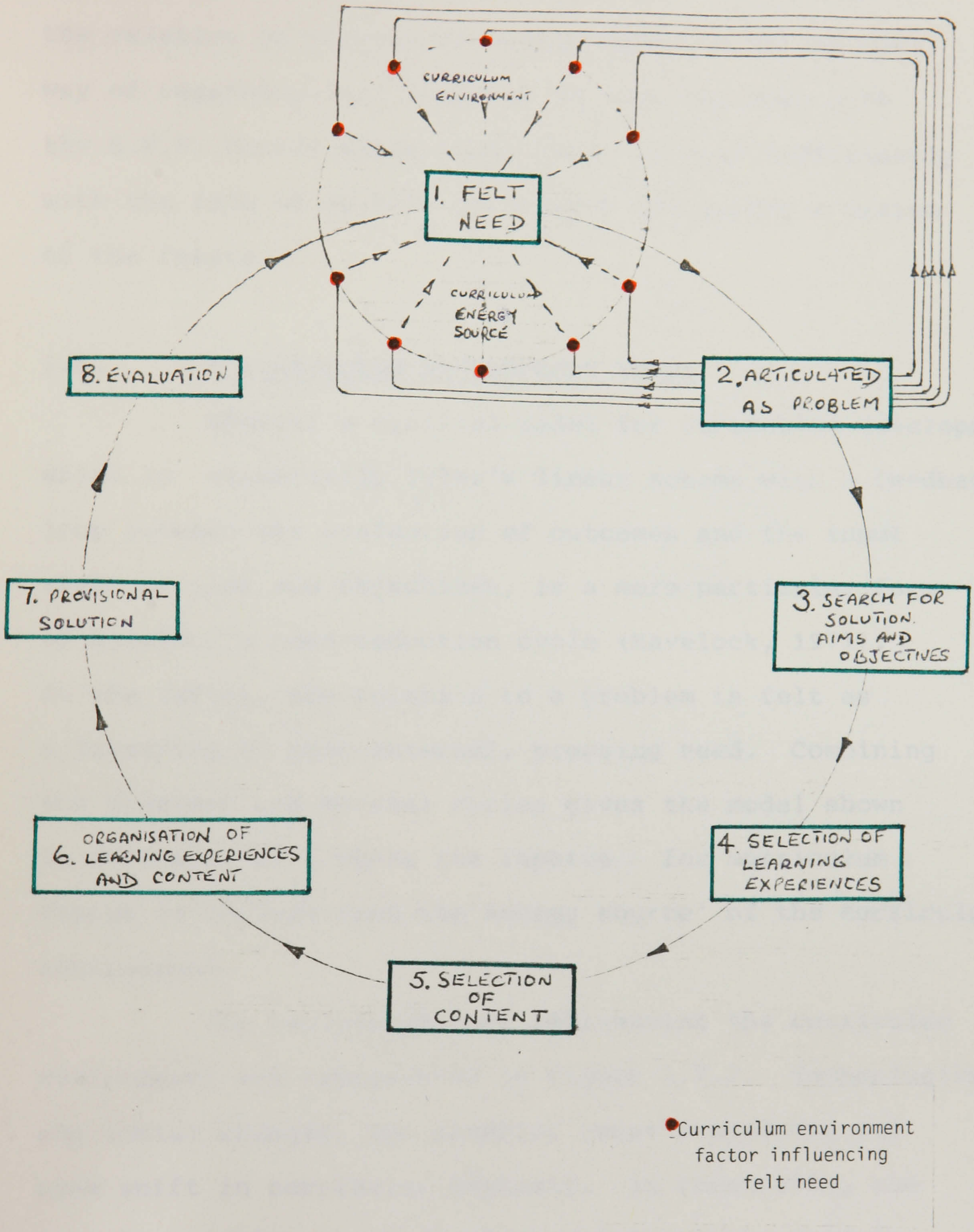
It was the European P.S.S.C. conference in the U.K. in 1961 which was to lead to the Nuffield science projects.

Back in the United States, P.S.S.C. physics had not arrested the swing away from physics in the high schools (Lewis,J. 1972). The other sciences and mathematics were holding their own, but such was the parlous state of physics that a further project was set up in 1964 at Harvard University - The Project Physics Course. In addition to the basic physical concepts, Harvard Project Physics (H.P.P.):

> "...stresses throughout the humanistic roots and consequences of science... the way physical ideas have developed and influenced contemporary culture; the personality and historical background of the men and women who made the key contributions....the interplay between the growth of physics, developing technology and its consequences for society." (Lewis, p334)

From the start H.P.P. included an evaluation team to monitor the effectiveness of the course material and learning experiences (Welch, 1974). Specific outcomes were assessed in what Welch called 'a true experimental design', and, as an example of a formative evaluation, were fed back into what was now a cyclical model of the curriculum (Wheeler, 1967) of the type appearing in figure 1.5.1. The result of this development is that the course has arrested the swing from physics in those schools where it has been adopted (Lewis) and has met its affective objectives in making physics more interesting and humanitarian (Welch). When Ahlgren and Walberg (1973) compared H.P.P., P.S.S.C. and traditional physics courses in terms of affective outcomes, P.S.S.C. fared

FIGURE 1.5.1 THE GENERAL CURRICULUM MODEL



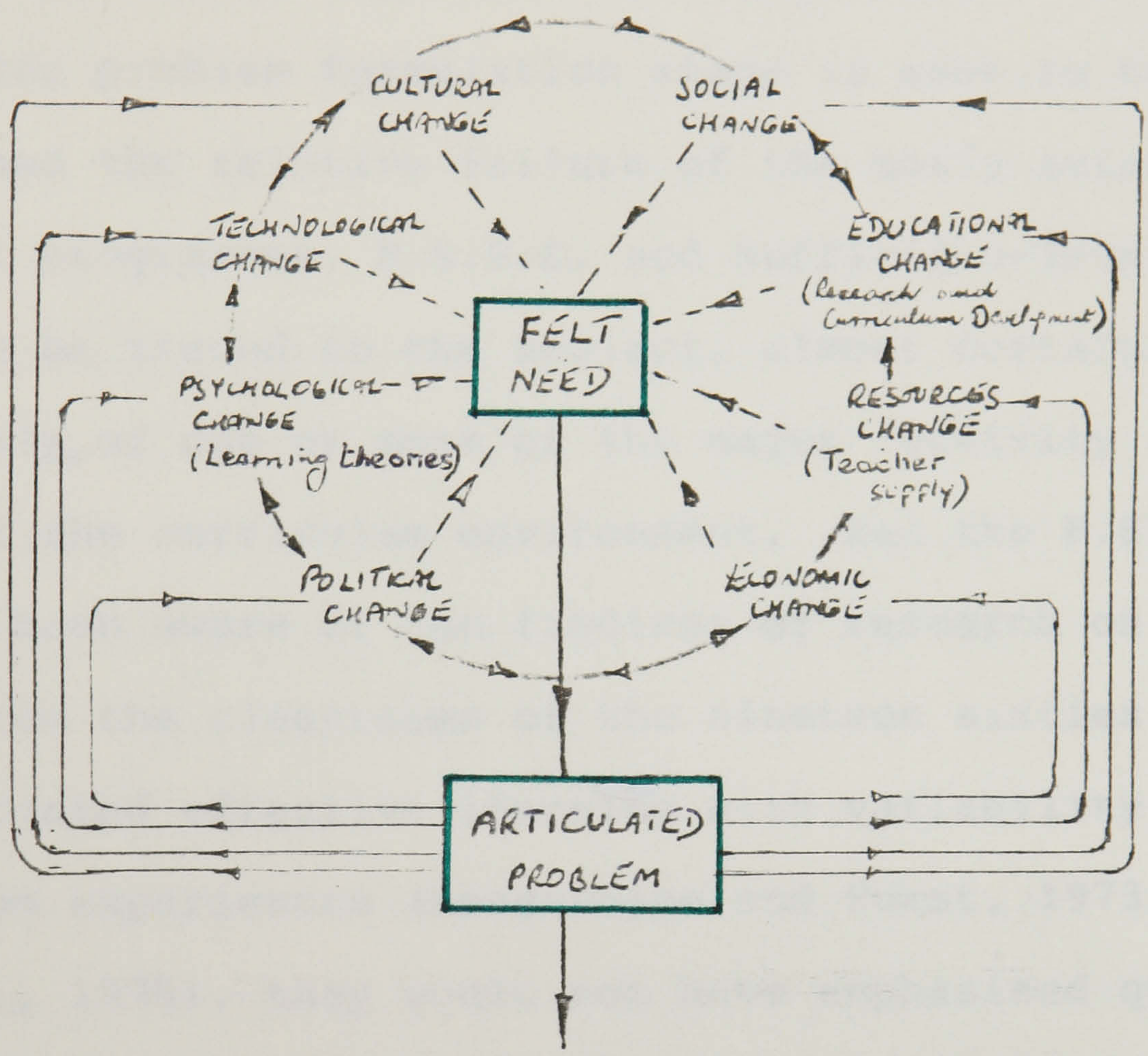
poorly even in relation to traditional physics. The two authors of this evaluation report conclude that the relation of science to people seems to be the best way of regaining lost interest in physics, even with the H.P.P. course,which still fails to deal sufficiently with the role of science in culture and giving a vision of the future.

1.5. A CURRICULUM DEVELOPMENT MODEL

Wheeler's cyclical model for curriculum development, which is essentially Tyler's linear scheme with a feedback loop between the evaluation of outcomes and the input stage of aims and objectives, is a more particular form of Havelock's need-reduction cycle (Havelock, 1971). In the latter, the solution to a problem is felt as a lessening of some external, pressing need. Combining the Havelock and Wheeler cycles gives the model shown in figure 1.5.1 , where the impetus for curriculum change is derived from the'energy source' of the curriculum environment.

The factors at work influencing the curriculum environment are represented in figure 1.5.2. Technological and social changes, for example, cause a pressure for some shift in curricular emphasis. In formulating the specific problem, several other related areas need to be explored to put the problem in the context of the whole curriculum environment. For instance the need to give pupils some experience of microelectronics (a

FIGURE 1.5.2. FACTORS INFLUENCING THE FELT NEED



change in technology) because of its increasing application in every day life (bringing about social changes) has to be interpreted in terms of current curriculum research in the area (educational change); resources that will be available, and the psychological implications of interacting with an electronic 'intelligence'.

The problem formulation stage is seen to be a key one and the relative failure of the early science development programmes, P.S.S.C. and Nuffield O-level physics can be traced to the neglect, almost certainly unconsciously, of one or more of the major 'activity centres' of the curriculum environment. Had the P.S.S.C. developers been aware of the findings of research on learning from the classrooms of the nineteen sixties, which associated effective learning with variability of classroom experiences (Rosenshine and Furst, 1973; Good et al., 1975), they would not have emphasised quite so much the P.S.S.C. textbook in learning, unlike the H.P.P. team who did use a researched, multi-media approach to supply variability. Had the Nuffield O-level physics team been more aware of the psychological base of learning, fewer difficult concepts and sophisticated thinking skills would have been demanded of the pupils (Meyer, 1970; Shayer, 1972; Gaskell, 1975).

Knowledge of the environmental context of the 'problem' in the curriculum cycle directs the search for a solution, and at this stage a clear statement of the purposes of the curriculum is made. The learning experiences, subject content and organisation needed to achieve the purposes or objectives then follow. A solution to the curriculum problem is now arrived at but must remain provisional until the outcomes have been evaluated. If the evaluation of the solution leads to a reduction in the felt need, the development procedure has had a measure of success. This type of evaluation is said to be formative; its results are fed into the curriculum environment energy sources to shape the next problem formulation and solution cycle.

The H.P.P. evaluation was essentially of the formative type: if objectives were not being attained, modifications of method, content or the objectives themselves could be made. On the other hand, the P.S.S.C. and Nuffield O-level physics evaluations were largely summative, although the timing of Meyer's investigation suggests that it could have been formative if, as Tawney pointed out, the full implications of evaluation in the curriculum had been realised.

Summative evaluations take place 'after the event'. The findings of these evaluations are not fed back immediately into the curriculum cycle as the initial development has now been 'packaged' and disseminated - an example of the 'research and development' approach to curriculum change, which in reality has tended to be disappointing (Hoyle, 1973). Instead, summative evaluation studies take their place in the curriculum environment and are drawn upon to power the curriculum development cycle when it starts up again. A summative evaluation of the P.S.S.C. course was effectively provided by the continuing swing against physics in the high schools, which subsequently energised the Harvard development cycles. In the U.K., summative evaluation of the syllabus content of all the Nuffield courses, not just O-level physics, has been taken into account by the G.C.E. examining boards (for example, University of London, 1981), and all syllabuses reflect this to a lesser or greater degree.

One aspect of both P.S.S.C. and Nuffield physics evaluations was formative. This was the testing of the trials materials in the schools to see if the experiments worked under practical conditions and whether the time allocation was suitable for teaching the course topics. Feedback was essentially subjective for the most part, content only was being evaluated but a rudimentary curriculum cycle was being operated (Wenham, 1967).

1.6. A SCIENCE OF TEACHING SCIENCE

The relative success of Harvard Project Physics in relation to the P.S.S.C. course has been identified with a greater awareness of a specific model for curriculum change and hence a knowledge of the need to match learning experiences with the needs of the learners. It is only by research in education that the learner-match can be investigated and appropriate experiences selected to permit specific curricular objectives to be achieved. Thus, it is necessary to develop, as far as is possible, a science of learning which will permit efficient and soundly based curriculum decision-making to solve educational problems, of which the swing from physics is typical.

In pursuit of a science of science teaching, Gardner (1975a) argues that much of current science education as practised in the classroom is unscientific, being based on tradition, habit and folklore. Teachers demonstrate practical know-how in abundance but demonstrate little awareness of a theory of what they are doing. Gardner poses the rhetorical question that a student might ask of the teacher:

> "What evidence do you have that the teaching methods you are using are effective?" (op.cit. p.xiii)

To this, says Gardner, there is no satisfactory reply. Yet research evidence by Gardner, himself, (1976) has shown that the result of the teacher-pupil interaction effect in the classroom can be greater than the effect of new curricular materials, and that the same teaching behaviour can have quite different effects on pupils of different personality type. Incidentally, differential teacher-pupil interactions could well play a part in some of the more ambiguous results in the summative evaluations of the early Nuffield projects.

In reviewing current practice in higher education, Becher et al. (1975) report that teaching in general is seen as a private, amateur activity: research in a discipline is pursued and experiences are shared, but there is little communication about research and structure in the teaching process. Entwistle and Wilson

(1977) see one of the functions of research in education as

> "...an irritant to 'conventional wisdom', challenging the validity of existing practices which may have become habitual." (op.cit. p158)

Good et al. (1975) point out that even strongly held beliefs about education can turn out to be in error once they have been subject to research. Their review of research, mainly in schools in the U.S.A., shows that schools and teachers do affect achievement and attitudes, but that the teacher behaviour-pupil outcome relationshiop is complex. In an attempt to unravel this relationshiop, Good and Power (1976) have identified five types of pupil in their research classrooms whose learning needs are quite different. Even if the existence of styles of learning and teaching for different pupil groups is established from further research, Good et al. (1975) warn that the type of teacher behaviour that maximises student learning might not overlap the type of behaviour needed to promote positive attitudes.

Further evidence of the need to unravel the pupil-teacher interaction before the nature of effective learning, and hence curricular change, can be understood comes from Alexander (1974), who in trying to explain why pupils' science interest fell more when following the Nuffield Secondary Science Course, pointed out that a study of teaching styles is at least as important as a study of subject content. A similar conclusion was made by Brown (1976), who reviewed the introduction of an integrated science scheme and also found a deterioration in attitudes. Sumner and Warburton (1972) reviewed and researched the factors relevant to the raising of the school leaving age in the U.K. They recommend that further research be conducted into the qualities of teachers to which different types of pupil respond and further suggested that the pupils themselves might be consulted as to the method of learning they might prefer. The potential contribution of the pupils to curriculum innovation was emphasised by Rosenhead (1968) who called for a study of their reasons why there was a swing from science in the nineteen sixties. Bondi (1975) has asked that 'market research' be conducted to find what is attractive in science to the young. That pupil opinion has some validity has been demonstrated by Pell (1977), who has shown that pupils' perceptions of an optimum science teaching style has strong theoretical justification. Having identified pupils' preferences, Ormerod (1975) suggests that the systematic classroom approach is for the teacher to match his style to the pupils' expressed profile; curricular designs should then correspond to these desirable teaching behaviours. Taking into account Good and Power's pupil types, it is apparent that the 'scientific' classroom is likely to require a range of teaching behaviours to match the pupil group structure of the class, with the teacher providing a variable approach to the learning of the subject material so that, at any one time, as many pupils as possible are working in a 'matched' environment (Rosenshine and Furst, 1973). There is evidence that the greater the pupil match, the greater the amount of learning (Crawley and Shrum, 1977).

1.7. THE AIMS OF THE PRESENT RESEARCH

The problem-solving, cyclical model for curriculum development can easily be applied to shape a curriculum research investigation such as that reported here. Already, the substance of the Introduction has activated the curriculum environment energy source (figure 1.5.1). To 'articulate the problem', some freedom of choice is permitted, for as Bennett and Entwistle (1977) have written:

> "Research workers cannot explain the whole educational process in a single study." (op.cit. p221)

Consequently, in an attempt to contribute towards a science of teaching science, factors relevant to the choice of physics at G.C.E. A-level are to be investigated with particular attention to

1 the affective domain of behaviours;

2 pupils' perceptions of their classrooms and teacher behaviour;

3 outcomes in terms of G.C.E. success and enjoyment of physics;

4 a typology of teachers;

5 the combinations of classroom personality and attitudinal variables that are associated with success and failure in the A-level physics course, and

6 a typology of physics pupils.

While some might wish to use the results of this research to 'correct' the statistical swing against A-level physics in the U.K., such a use would be incidental. The main purpose is to show that a 'curriculum science' can be applied to the organisation of the physics classroom, and by implication to science education generally. For the ordinary physics teacher, guidelines for improved practice might reasonably be expected to emerge. The philosophy of this type of research has been well expressed by Carter (1972), although in referring to higher rather than secondary education,

> "The purpose of research into...education,for most of us, is a practical one. We do not want merely to describe the quaint or awful things which are going on: we want to make things better... So I hope in planning research, you will... see if your colleagues can be helped with some of the simple and obvious faults which have persisted in... education for too long."
> (op.cit. pp1-3)

The research planned in the present study is essentially a summative evaluation of G.C.E. physics education as described by stages 3 to 6 in the curriculum model; namely, an evaluation of physics content and learning experiences with the emphasis on the latter, as content is largely prescribed by G.C.E. examination syllabuses. Teachers and other researchers will wish to evaluate (stage 8) the provisional solution (stage 7) before setting off around the curriculum development circuit themselves.

1.8. THE STRUCTURE OF THIS REPORT

The first formulation of the 'articulated problem' in the curriculum cycle is followed by several return visits to the curriculum environment of research, psychological, cultural, social... influences to refine the problem into a testable form. This is the purpose of chapter 2, where a Review of Earlier Work draws upon as much relevant information as possible. Chapter 3, The Research Hypotheses, is a distillate of Chapter 2: in terms of the curriculum cycle, it states the 'aims and objectives' which are to be tested. Chapters 4 and 5 describe the construction and use of the test instruments. Chapters 6, 7, 8 and 9 report the test results for the teacher and pupil sub-samples. In Chapter 10, objectives are evaluated and a provisional curriculum solution is discussed in terms of the implications for

1 the teachers

2 the pupils

3 the science of teaching science

CHAPTER 2

A REVIEW OF EARLIER WORK

2.1. THE AREA FOR REVIEW

In Section 1.7, the broad aims of this investigation focused upon the collection of evidence on

a) pupil attitudes towards physics,

b) pupil attitudes towards academic study and their possible interaction with personality,

c) pupils' perceptions of their learning environment,

d) typologies of teacher and pupils,

e) factors relevant to the choice of physics at G.C.E. A-level, and

f) multiple-variable description of classrooms and pupils in relation to enjoyment and achievement outcomes.

The Review which follows takes each of these areas in turn but the nature of the earlier research studies, inevitably means that studies and areas overlap from time to time.

2.2. MEASURING PUPILS' ATTITUDES TOWARDS SCIENCE AND PHYSICS

In a rigorous criticism of the theoretical base of science interest scales, Gardner (1975b) lists a number of attitude tests that have been used in recent research.

Many are shown to be deficient in the lack of a firm underlying theoretical construct: others are of questionable reliability and validity. Two tests appear to be of merit: the one used by Gardner (1976) himself, in Melbourne, and the Science Attitude Questionnaire developed by the National Foundation for Educational Research (Skurnik and Jeffs, 1970). However, the latter does contain some doubtful items (Gardner, 1974: Alexander, 1974), while Gardner's tests and sub-scales are somewhat lengthy.

The Science Attitude Questionnaire has been further revised by a team working on a Schools Council project (Galton, Eggleston and Jones, 1975). A 30-item composite attitude scale has been developed, but still including those items termed suspect by Gardner, after separate factor analyses for samples of biology, chemistry and physics pupils. Five factors were identified, independent of the subject sample and were termed

i) the fun factor,

ii) the practical investigators,

iii) the committed scientists,

iv) the concrete scientists, and

v) the career scientists.

Both the Schools Council and the Australian attitude projects used scales in pre-test and post-test designs, and both showed that attitudes deteriorated over the course, which was of about eight months duration in each case. However, attitude deterioration seems to be a very common research finding. Choppin (1974) in the

N.F.E.R. evaluation referred to in Section 1.3. used a simple 'like-dislike' rating scale with third-, fourth- and fifth-form pupils to show a rapid decline in popularity for physics and chemistry : girls showed poorer attitudes in absolute terms and just as great a deterioration as the boys. In the United States, Rothman (1969) reports that attitudes towards Harvard Project Physics deteriorate even when accompanied by otherwise desirable teaching behaviours which appear to bring about improvements in understanding.

Also in the context of U.S.A. educational research, Stevens and Atwood (1978) have investigated the variation in science interest scores in samples of 13-15 year olds. Again over the school year, for all the three grades it was found that significant deteriorations occurred, although at the start of the year the interest scores were comparable across the grades. They suggest that their results are indicative of two factors at work in the science classrooms:

i) a general 'school fatigue' effect, which comes into play as the year progresses to depress the interest scores; as next year, 'things will be better', scores tend to recover during the summer vacation;

ii) the existence of an as yet undiscovered interaction between curriculum and teacher which negatively affects interest.

The first hypothesis is attractive but is unable to explain Choppin's findings of a consistent year by year deterioration.

Indeed, Choppin goes on to remark that this age effect on attitudes, together with strong sex differences tend to blur any course differences (between 'Nuffield' and 'traditional' courses).

Reference to the relative unattractiveness of physics was made in Section 1.2. Duckworth (1972), who was responsible for probably the first systematic investigation of relative attitudes towards a range of school subjects, developed in association with Entwistle, a repertory-grid method for comparing subjects on a number of bi-polar construct scales (Duckworth and Entwistle, 1974a). Factor analysis of the responses showed that pupils were using four main attitudinal factors to distinguish between subjects. These factors were (i) interest (ii) difficulty (iii) freedom and (iv) social benefit . In the fifth-form, physics was rated the most difficult of the nine subjects in the study. On 'interest', physics appeared in the lower half of the scale. These attitude ratings were the same for both boys and girls. With a less sophisticated series of scales, Hockey and McKim (1968), had obtained similar results with a group of lower sixth-form students in a public school. Pell (1975, 1977) followed the repertory-grid approach of Duckworth and Entwistle with a sample of comprehensive and grammar school fifth-form pupils to confirm that physics is rated the most difficult of the major 0-level subjects and occupies a low position on the interest scale.

An extensive survey of the subject preferences of pupils in the third-form has been conducted by Ormerod (1975). He reports only a slight correlation with Duckworth's rank-orders. He attributes some of this difference to the respective age-ranges of the samples, but a further area of incompatibility is likely to be the disparate nature of the two 'interest' scales. Ormerod's study is notable for demonstrating (i) high correlations between subject 'liking' and teacher popularity and (ii) sex differences in attitudes (see Section 2.4).

Although it is possible to criticise the reliability of the various subject rank-order lists and even acknowledging the problem of over-generalising social research findings (Shipman, 1972), it seems most likely that physics is perceived as one of the most difficult, if not the most difficult subject, in the secondary school curriculum; that it is not particularly well liked, and that interest deteriorates with time.

2.3. ATTITUDES AND ATTAINMENT

In his attitude review, Gardner (1975b) points out that the correlation between attitudes and attainment in science are relatively weak. In some instances, positive associations might be partly due to items on the attitude scale being implicity attainment oriented: a criticism which might be directed towards the Science Attitude Questionnaire in both revised and unrevised forms (Nuttall, 1971 and Galton et al., 1975).

An international survey of subject attitudes and achievement in nineteen countries has been reported by Comber and Keeves (1973). In all, one quarter of a million pupils took part at ages of 11 years, 14 years and 18 years. For the two eldest groups, a positive association between science achievement and interest is reported, but again there are doubts about the suitability of the attitude scales: doubts expressed by the authors of the report themselves.

The evaluation of Harvard Project Physics included an investigation of the gain in achievement and course grades with satisfaction. Welch (1969) reports a significant positive association.

Reference has been made earlier (Section 2.2) to the study of Stevens and Atwood which monitored interest changes in Junior High Schools. They discovered that interest scores had a significant, though minor effect, on predicting post-performance scores.

Duckworth's survey of six English grammar schools (Duckworth and Entwistle, 1974a) showed that interest scores in mathematics and the physical sciences generally gave higher positive associations with attainment than were shown with 'easier' subjects such as biology and English.

Given an association, albeit slight, between attainment and attitudes in science, can it be said that changes in attainment cause changes in attitude or vice versa? Hilton and Berglund (1974) have suggested that the interaction between these two variables is probably instantaneous, with for instance positive feedback through the comments of the teacher. In their view, all a statistical survey can do is to demonstrate a close association between such variables, if one exists. Elton (1977) supports this hypothesis, that learning and enjoying occur simultaneously, and states that it is meaningless to talk of a causal relationship in this context. However, Eisenhardt (1977) in a longitudinal survey of seventy thousand students measured interest and achievement scores over a two year period in four subjects, including science. He claims that changes in achievement level cause changes in interest level more often than vice-versa.

2.4. SEX DIFFERENCES IN ATTITUDES

The sex variable is a major one in the measurement of attitudes to science. In Gardner's words

> "probably the single most important variable."
> (Gardner, 1975b, p22)

A survey conducted by Her Majesty's Inspectorate for the Department of Education and Science (D.E.S., 1975) showed that in the fourth-forms of English schools in the Autumn of 1973, some 47% of boys but only 12% of girls were studying physics. The corresponding figures for biology were 28% and 49%, respectively. In the sixth-form, 41% of all boys taking A-level subjects would be studying physics, which with mathematics is the highest proportion for all the major subjects. At this level, only 9% of all girls taking A-level subjects would be studying physics, which is comfortably the smallest proportion amongst the major subjects.

The D.E.S. survey shows that girls in the sixth-form are more likely to be studying the physical sciences or mathematics if they are in a single-sex school, which lends support to the hypothesis (Ormerod, 1975) that these three subjects are perceived by the pupils as 'male', so in a co-educational environment girls are more likely to play-out their expected sex role and choose other less obviously 'male' subjects.

The international survey reported by Comber and Keeves showed that sex differences in both attitudes and science achievement are a world-wide phenomena. Differences favour the boys and the achievement gap widens with age. The largest cognitive differences are shown in science understanding. The results for biology show that this science is more attractive to girls, internationally, which confirms the D.E.S. survey findings. Gardner (1975b) points out that the enrolment patterns at school level carry on into university education and into the science teaching profession, where physics teaching is almost exclusively a male vocation.

Both the Schools Council survey (Eggleston et al., 1976) and Choppin's new curricula review (1974) illustrate clearly the attitudinal differences between boys and girls in the three sciences. Taking the former study as an example (Section 2.2), the Science Attitude Questionnaire was administered to fourth-form pupils in a pre- and post-test design. Boys showed superior enjoyment in physics and chemistry on both tests: in biology, the early superiority of the boys had disappeared by the post-test. Eggleston et al. comment:

> "The results thus confirm the findings of other attitude studies of science... All pupils tend to respond less favourably as the course progresses, and the female pupils are less enthusiastic than their male counterparts even at the initial stage."
>
> (op.cit. p.95)

Why should there be these attitudinal and cognitive differences between the sexes in science education? In a literature and research review, Saraga (1975) discusses the contributions made by differences in inherent biological characteristics of the sexes and by traditional social expectations of role-behaviour. She concludes that a major, significant difference in favour of boys is their problem-solving ability - their ability to break down a problem in an analytic task. When this, accompanied by a strong task-achievement motivation deficiency, is allied with a rigid sex-role stereotyping in school, as it usually is, girls tend to react away from science. Kelly (1975) takes the social conditioning effect on girls further, and sees girls entering secondary school as

a) more interested people,

b) less experienced with mechanical and electrical toys and gadgets,

c) having less spatial but more verbal ability,

d) less independent and less likely to embark upon tasks requiring initiative,

e) more conscientious and more likely to study by rote learning, and

f) less self-confident and more easily discouraged by inability to understand.

Kelly points out that although there are real differences in group attitudes and abilities between the sexes, there are girls who are above the norm for boys and who are experienced with gadgets and are interested in science. Even so, writes Kelly, for most girls

> "With modern syllabuses (Nuffield), rote learning is often impossible and, where understanding is beyond her, a conscientious girl is left with nothing but dislike for the subject."
>
> (op.cit. p.8)

It appears that girls who are successful in science, and in the physical sciences in particular, are atypical of girls generally. Duckworth and Entwistle (1974a) identified a group of 'female scientists' at the age of 12 years in a grammar school survey (Section 1.2), who showed inter-correlated interest scores in mathematics, physics and chemistry. Hutchings et al. (1975) found that girls studying the physical sciences in the sixth-form comprised a separate, highly intelligent personality group with unusually low person-orientation scores. In general, pupils studying the physical sciences at this level are amongst the most intelligent in the school population (Duckworth, 1972; Hutchings et al. 1975), and Pell (1975; 1977) has shown that unlike the attitudes of younger pupils, there are no significant sex differences in attitudes towards science for physics students in the fifth- and sixth-forms. Duckworth's investigation resulted in the remarkable finding that the male characteristics of sixth-form science choosers, namely high academic motivation, good all-round knowledge, an antipathy towards arts subjects and an introverted personality were also the characteristics of the girl science-choosers, but to an even greater degree.

Evidence from the U.S.A. in the form of the Harvard Project Physics (H.P.P.) evaluation confirms the unusual attributes of girl physical science choosers. Walberg (1969a) places the boys and girls on the H.P.P. course in the top 16% of the ability range. Girls scored significantly higher than the boys on three of four cognitive measures with the boys doing better on a test of quantitative and spatial abilities. On a test of values, both the boys and girls showed a masculine bias when scores were compared with population norms. Girls saw experiments in physics as more important than did boys but at the same time more difficult. In an earlier evaluation, Walberg (1967) had found that girls following the H.P.P. course scored lower on a 'tinkering' activities scale than the boys: the latter, not unsurprisingly, were more likely to prefer electronic repairing, for instance. So it appears that girl physicists continue to exercise part of their sex-stereotype role but from within an otherwise strongly masculine and elitist position. This hypothesis is supported by other results from Walberg's first evaluation: girls expressed a significantly stronger academic interest in science than boys and were more likely to want to apply their knowledge to living things, animals as well as people. Further, girls scored lower on a 'cosmology' scale, which in Walberg's view is a clear demonstration of the girls' femininity in finding 'cosmological thoughts' unattractive.

In conclusion, the unpopularity of physics with the majority of girls appears to lie in the mismatch of the nature of the subject, as it is currently taught, and the cognitive thinking style and interest of the pupils. The latter might have some inherent biological origin but social conditioning is a major factor. Despite social, and perhaps natural, obstacles, some girls do study physics and the physical sciences. In academic terms, these girls display strongly masculine characteristics. This might be indicative of a deeply held motivation to succeed in physical science despite the obvious, imposed difficulties, for the girls still exercise their femininity, although this is subsumed in their overall achievement motivation.

2.5. MOTIVATION, STUDY METHODS AND PERSONALITY

There have been indications from Section 2.4 that science pupils might form a distinctive personality group in the secondary school. Reference has also been made (Section 1.6.) to Gardner's study of students following the P.S.S.C. course in Melbourne (Gardner, 1976): he writes

> "...the same teaching behaviour can have markedly different effects depending upon the personality of the pupil."
>
> (op.cit.p.123)

A study of recent research literature shows two personality instruments in regular use in the U.K. These are the Eysenck and the Cattell scales, (Eysenck and Eysenck, 1964; Cattell et al., 1970) In a comparative evaluation of personality inventories, Buros (1972) points out the severe limitations of the multi-dimension Cattell version, although this instrument is still used from time to time in research in the U.K., for instance by Sumner and Warburton (1972) Josephs and Smithers (1975) and Hutchings et al. (1975). Entwistle (1973), in a general review of the influence of personality on academic attainment in the U.K., draws attention to the low reliability of the Cattell scales, partly due to their shortness, and queries the appropriateness of these scales written for use in the United States. Eysenck has investigated the Cattell inventory (Eysenck and Eysenck, 1969), and, while confirming the suspect nature of Cattell's sixteen primary personality factors, he was able to show that these could be reduced to the two higher order factors of extraversion and neuroticism, which are the two virtually orthogonal factors measured by the Eysenck Personality Inventory (Eysenck and Eysenck, 1964) and for which substantial psychological evidence has been collected (Eysenck 1972a, and Eysenck and Eysenck, 1969).

The Eysenck Inventory has the added attraction of a 'lie' scale to detect faked responses. However, Buros warns that this scale should be used with caution because of its weaker research base. There is some evidence of validity for the lie scale (Eysenck and Eysenck, 1964) but few studies that employ the extraversion and neuroticism, or anxiety, scales make reference to it. In an investigation of the relationships between personality, study methods and academic performance conducted by Entwistle and Entwistle (1970), the lie scale appeared to be measuring correctness in social behaviour rather than a faking of responses. Eysenck and Eysenck (1976) have since presented further evidence on the nature of the lie scale. They conclude that the scale is bi-dimensional: under some circumstances measuring faked responses but other times measuring a specific, consistent personality attribute stresssing genuine conformity to social rules and orthodox behaviour.

Eysenck (1972a) argues that psychological studies must be refined by including personality measurement if consistency of findings is desired. In a research review (Eysenck, 1972b), he points out that introverts have been found to be more successful in the study of the 'hard' sciences (biology and the physical sciences), and that introverts do better, generally, in the secondary school, while extraverts are superior in the primary school. In terms of the stability/anxiety dimension, it is the anxious students who need guidance on how to prepare for examinations. Finally, Eysenck suggests that interaction studies are needed to investigate the effect of sex, ability and subject choice with personality.

A review by Entwistle (1973) focuses upon the relationship between personality and academic attainment. Students in higher education following a range of disciplines were investigated (Entwistle and Wilson, 1977). Pure science students were found to be stable introverts, whereas applied scientists or engineers were most likely to be neurotic introverts. The more academically successful students tended to have the more extreme personality scores. Entwistle concludes that although introversion is strongly associated with success in secondary and higher education, the other orthogonal personality attribute of anxiety varies with achievement according to sex and subject area. Expanding upon Eysenck's reference to the uncertain study methods of anxious pupils, Entwistle suggests that a full interpretation of anxiety or stability scores needs an accompanying knowledge of the pupil's actual study habits as well as the pupil's motivation towards academic success and cognitive study-style.

Cognitive study style, commonly called syllabus-boundness, was identified by Hudson (1968) in a small survey of high ability schoolboys. Pupils specialising in the physical sciences were more likely to be syllabus-bound; that is, to favour a narrow, restricted approach to studying, where the mode of learning is highly prescriptive, consistent and structured. The other pole of this study dimension is 'syllabus-freedom', a characteristic of arts specialists. Parlett (1970) has used the syllabus-bound concept in a U.S.A. college study. His conclusions were that syllabus-bound students are more likely to be oriented towards examinations; are more likely to do more homework; are less likely to do well on projects (where the learning structure is ambiguous), and are less likely to be affected by strong personal interests. Parlett suggests that the syllabus-bound student is the one more likely to be suited to normal, traditional science: a syllabus-free science student would be attracted to a creative, revolutionary science - the 'science' of an Albert Einstein. Although it might be supposed that the pupils who prefer a highly structured approach to learning would adopt the most desirable study habits, both Parlett and Hudson found no significant association between syllabus-boundness and study-habit scores. Smithers et al. (1975) have reported finding a positive correlation between attainment at university and syllabus boundness for male students. However, Entwistle et al. (1974) have criticised the early syllabus-boundness scales as being two dimensional and hence difficult to interpret. Even with more valid measures of syllabus boundness, Entwistle et al. suggest that curvilinear attainment relationships might be expected with moderate syllabus boundness scores correlating with achievement but high scores indicating obsessiveness.

Extensive investigations into the relationships between motivation, study methods and personality in the secondary school and at university have been undertaken at Aberdeen and Lancaster over the decade beginning in the late nineteen sixties. Prior to these U.K. studies, the only motivation/study habits scales available were from the U.S.A. (Buros, 1972). After some preliminary work at Aberdeen, Nisbet and Entwistle (1969) developed a motivation scale for use in the lower age range of the secondary school. They were able to show that academic motivation showed an increasing correlation with attainment as the pupils became older. Moving to Lancaster, Entwistle became associated with a project sponsored by the Rowntree Trust into the characteristics of successful students in higher education and the educational purposes of such institutions (Entwistle et al. 1971a). The Rowntree student project made use of specially developed study methods/motivation, (study orientation) scales with the Eysenck inventory to determine personality characteristics. The results of this area of the project have been widely reported in a series of earlier papers (Entwistle et al. 1971b; Entwistle and Cowell, 1971; Entwistle and Wilson, 1970). The contributions of study orientation and personality to success in higher education, and a detailed report of Entwistle's work at Lancaster and a similar study conducted by Wilson at Aberdeen, have recently appeared under joint authorship in 'Degrees of Excellence' (Entwistle and Wilson, 1977).

The Rowntree study-orientation scales used the

Brown-Holtzman "Survey of Study Habits and Attitudes" (S.S.H.A.) from the U.S.A. as a starting point. The American scales were modified and tested in the British student environment (Entwistle et al., 1971b), until two reliable, valid scales measuring study attitudes and academic motivation were obtained that showed strong intercorrelations with the sub-scales of the S.S.H.A. (Cowell, 1970). Although designed for use at the level of higher education, the majority of the items on the two Rowntree scales can be judged suitable for the upper reaches of the secondary school and the remainder need only a minor rewording to make them so. One remaining problem with these two scales, however, is the lack of face validity in the allocation of some of the items to the sub-scales of study habits and motivation (Entwistle and Wilson, 1977).

The findings of the personality-study orientation studies at Lancaster and Aberdeen have been somewhat equivocal. Whilst students with low neuroticism scores ('stable' students) generally have the better study orientation, the relationship between the extraversion dimension and study orientation is less clear. In a sample of technical college students, Cowell found that stable introverts had both superior study methods and motivation scores. Diploma of Education students at Aberdeen who had the highest motivation scores tended to be stable introverts, but on the study methods scale it was the unstable introverts who tended to score highest (Entwistle and Wilson, 1970). With a very large sample of students from a range of higher educational institutions, Entwistle et al. (1971b) showed that stable students tended to be the most highly motivated with the best study habits but any extraversion relationships were weak.

Further information on studies conducted elsewhere is very sparse. Hartley et al. (1971) attempted to improve on Entwistle's lower secondary school motivation scale (Nisbet and Entwistle, 1969) before using the amended form to investigate, inconclusively, programmed learning in chemistry with thirteen year-olds. Probably a fair comment is that it is the apparent lack of a suitable study orientation test which has prevented data from being gathered in the senior secondary age range to extend the higher education studies into the school system. Entwistle and Wilson (1970) conclude for students in higher education -

> "Temperamentally, introverts appear to have an advantage in both study and taking examinations, but it may still be possible to improve the poor study methods of extraverts by systematic instruction in study strategy."
>
> (op.cit. p155)

It is not unreasonable to expect similar findings from the senior secondary school but, at the present time, real evidence is still awaited.

Apart from the Nisbet and Entwistle survey, to which reference has been made previously, relationships between academic motivation and attainment have generally been found to be weak if any relationship exists at all. Hartley et al. (1971) suggest that a general measure of academic motivation might be inappropriate in the context of a specific subject area. Weiner (1972) points out, though, that the concept of motivation is more complex than the early simplified rating scales might imply. Whereas many studies show that motivation is not related to achievement, if a distinction was drawn with a specific 'fear-of-failure' motivation, significant associations did appear. This form of motivation expresses a drive to succeed to maintain one's self-esteem and to prevent the social and mental 'disgrace' of having failed in a task. Weiner shows that achievement and fear-of-failure are negatively related. High fear-of-failure scores tend to have already experienced failure and to be low achievers. Entwistle and Wilson (1977) also identified fear-of-failure motivation amongst the university students in their surveys. Students strongly exhibiting fear-of-failure tended to lack confidence and be anxious, yet many still achieved good degrees.

In a review of the suitability of the Rowntree motivation scale, Entwistle and Wilson conclude that it measures a combination of intrinsic and academic achievement motivation. The former is the drive to pursue chosen academic subjects because of an involvement and interest in the subjects for their own sake : the natural interest and curiosity of the student leads to a continual need to satisfy the intellect. Academic achievement motivation is the drive to demonstrate success in mastering academic subject knowledge and its structure: this motivation dimension includes a competitive element. The complement of intrinsic motivation is the need to satisfy some external pressure for academic success (Peters, 1958) - this is extrinsic motivation, which as Entwistle and Wilson point out, characterises some unsuccessful students at university whose presence in higher education is likely to be due to 'extrinsic' parental pressure rather than 'intrinsic' academic need.

An attempt is being made by Entwistle (1977) to investigate systematically the complex web of relationships between attainment motivation, study methods, personality and cognitive study style. This Social Science Research Council (S.S.R.C.) sponsored project has permitted the development of appropriate, modified study and motivation scales but no results are yet available. Even so, there is some reason to believe that there are fundamental group differences in thinking styles between science and arts students. The former tend to be more introverted and are better able to impose structure on the information which they acquire, matching as Entwistle points out, the demands of their scientific discipline.

Gardner's extensive review of attitudes to science (Gardner 1975b) makes little reference to the study methods and motivation variables, although one of his own studies (Gardner, 1974) did show that achievement motivated students expressed a greater interest in physics. A study by Soh (1973) of second-form boys in three grammar schools divided pupils into potential scientists and non-scientists, according to ratings of likely careers. He found that the 'scientists' had the higher achievement motivation and felt less need to assert themselves, being more concerned with school and family. Soh comments that the 'scientists' have been more successfully socialised, enjoying more pleasant relations with authority figures. Although Soh did not use the Eysenck Personality Inventory, it is interesting to speculate upon the outcome in terms of 'lie' scores if he had (Eysenck et al. 1971). It seems likely that the 'scientists' would score highly on this 'social conformity' factor.

A survey of 300 pupils in the first three years of the secondary school by Wilkinson (1975) showed that attitudes in science were significantly related to achievement motivation and to a stable personality. Duckworth's study identified high academic motivation as a characteristic of fifth-formers opting to specialise in A-level science. the most successful pupils in the sciences at 0-level were stable introverts. Leith (1973) argues that the relative success of introverts and extraverts in school learning reflects the methods of instruction employed. In a study of first-formers learning with teaching machines, he was able to show that extraverts learn better in loosely structured or 'discovery' situations whereas introverts are more successful when the learning is closely guided and structured. This finding strengthens the belief that physical science as conventionally taught, as a hierarchy of linked concepts built upon a factual base (Gagné, 1970), shows a close affinity with the introvert's 'natural' learning style. Extraverts are at an immediate disadvantage in studying physical science in the secondary school, and it is not unsurprising to find the extraversion trait is a major handicap in the study of science (Duckworth, 1972: Eysenck, 1972a: Entwistle 1973: Ormerod with Duckworth 1975: Entwistle and Wilson, 1977).

Gardner (1975b) concludes his review of the impact of pupil personality on attitudes to science by remarking that

> "students who are favourably inclined towards science tend to be relatively serious and achievement-oriented, realistic and independent but conventional and conformist." (op.cit. p.22)

To this can now be added the strong likelihood that science students are introverted; display a distinctive, structured cognitive thinking style, and are syllabus bound. Like students in other disciplines, science students might be expected to display a range of motivational attributes, from fear-of-failure to extrinsic and intrinsic motivation. To such students, the same teaching behaviour can have markedly different effects on attitudes and attainment according to the motivational state, thinking and study styles and personality of the student (pace Gardner, page 38).

2.6 PUPILS' PERCEPTIONS OF THE SCIENCE LEARNING ENVIRONMENT

When reviewing research or speculating upon directions for enquiry into the quality of exchanges in classrooms, it is not uncommon to find a call for some systematic, objective evidence from the perceptions of the pupils being taught (e.g. Wheeler, 1967). There is certainly a need, as Eggleston et al. (1976) have pointed out, for a systematic observation of teacher behaviours in order to meaningfully generalise from the results of classroom research. However, the teacher behaviour observed by the researcher on visits to the classroom is not necessarily seen by the pupils themselves in the same way. Shulman and Tamir (1973) make the point that

> "it may be that the way in which students perceive the learning environment accounts for achievement better than an apparently objective description of classroom activities."
> (op.cit. p.1136)

This viewpoint is expanded by Power (1977) who draws attention to the limitations of the structured observational instruments: they give little information on the physical, social and aesthetic qualities of classroom events, for instance.

Ratings of the classroom environment by the pupils themselves can show a surprising validity (Pell, 1977 and Section 1.6). In a review of a number of studies, Rosenshine (1971) writes

> "As a research variable, student general ratings have a particularly good history."
> (op.cit. p.182)

One of the conclusions drawn by Sumner and Warburton (1972) in their research in preparation for the Raising of the SchoolLeaving Age in the U.K. was that in some cases:

> "Teachers might ask their pupils informally which modes of work are preferred, and introduce the variants..."
> (op. cit. p.149)

Ormerod and Duckworth (1975) in their review of pupils' attitudes to science are led to conclude, essentially, that having identified the pupils' learning style or styles, a teaching method has to be adopted to give a 'best fit'. Curriculum designs should then be chosen which are sympathetic to the teacher-pupil interaction.

Crawley and Shrum (1977) have considered the hypothesis that the greater the match between the pupil preferred learning style and the actual teacher imposed structure then the more effective the learning (Vinton, 1972). They extend this hypothesis to a possible association between a 'matched' learning situation and improved attitudes after finding that first year university science students showed a greater preference for physics learning when in a compatible environment. Crawley and Shrum suggest that having to learn in a mis-matched environment results in negative attitudes being acquired and as the needs of individual students are likely to be different, a varied, teaching approach is highly desirable, which is a conclusion arrived at independently by a number of researchers (Rosenshine and Furst, 1973; Entwistle, 1973; Houston, 1975, for instance) using different criteria.

The Harvard Project Physics evaluation made extensive use of student rating scales (Anderson and Walberg, 1968; Walberg and Anderson, 1968; Walberg, 1969a/b; Welch, 1969; Smith et al. 1968; Smith, 1969). Walberg and Anderson found that:

1. students who show the greatest gains in physics achievement tend to be in socially homogeneous, close-knit classes working towards a single goal;

2. positive attitudes to physics are most likely to arise when students perceive their classes as satisfying, with little internal friction and having clear goals, and
3. gain in physics interst is found to correlate most highly with the perception of an organised classroom environment.

Smith asked students to rate the audio and visual media used on the Harvard course as well as the teaching medium (lecture, text-book method etc.). He concluded that the ratings of the various media seemed to reflect the length of their tradition as teaching aids (Smith et al. 1968). Overhead transparencies and 8 mm film-loops were given a rather low rating, but Smith warns against generalising across a medium and suggests that the content and presentation within a medium is the important factor. He recommends that:

1. the lecture should be used sparingly, to sum up and put in perspective;
2. a standard text should not be the central focus for learning, and that
3. the instructional load should be distributed across many media (the 'multi-media' approach).

These early research studies on pupils' perceptions of their classrooms, while hinting at the importance of matching the learning environment to the pupil, have not been particularly helpful to the ordinary teacher. The demand is for 'variability' in teaching behaviour and classroom tasks, but the parameters of this variability are not clear. This is partly due to the relative scarcity of scales designed to measure pupils perceptions and preferences. Gardner (1976) has obtained preference data with a scale comprising as many as 80 items. This scale was able to show that teachers perceived as organised, enthusiastic and achievement 'pressing' were able to sustain physics enjoyment with pupils of similar characteristics (Section 2.2 refers to attitude deterioration as the 'norm' in science classes). Less achievement oriented pupils were unhappy in this environment. In the U.S.A., Anderson and Walberg (1976) have developed the Learning Environment Inventory (105 items)from some of the earlier Harvard Project Physics scales. Pell (1975) has used a much shorter check-list of some 23 items to investigate 0-level physics classrooms. He found an overall, preferred style for physics teaching where there was

1. a strong teacher guidance element;
2. an interesting and varied presentation of lesson content with the use of audio-visual techniques;
3. group experimental work in well organised and smooth running classes;
4. learning by means of simple verbal, rather than mathematical, concepts, which are linked hierarchically, and
5. notemaking by a range of methods.

Theoretical support for this consensus profile is supplied by Houston (1975) and Gagné (1970). The latter sees the establishment of a hierarchical sequence of concepts, with cognitive rule learning being partly achieved by practical work, as the optimum science learning process. Pell obtained a similar broad profile of preferred classroom behaviours when A-level physics students were questioned.

The pupils perceptions of reality in Pell's study clearly identified where 'mis-match'was occurring. At O-level most pupils did not experience a varied and interesting learning environment, neither did they think that a simple, verbal concept hierarchy was established. This leads Pell to conclude that his check-list method has identified areas under the direct control of the teacher which could be manipulated to lessen subject difficulty and dislike, and hence increase numbers taking the subject at A-level. Sixth-form physics students were more satisfied with their learning environments but, again, the comparison of preferences with perceptions of reality allowed positive proposals for a learning 'match' to be made.

In an investigation of the relative teaching methods in the sixth-form and at university, Wankowski (1974) used a very coarse scale of two-way/one-way communication. The latter, more negative pole of the scale, describes a learning environment where questions and discussion are not encouraged. Wankowski found that 82% of his sample of 44 former A-level physics students had been taught in one-way communication classes, which compared with a proportion of 57% for all students in all subjects. For science students, Wankowski found that A-level grades tended to be better when the teaching was two-way, but overall, he concluded that science subjects in the sixth-form were more formalised and teaching behaviour more circumscribed than in the humanities.

Measuring pupils' perceptions of classroom events and matching these perceptions with preferred learning experiences appears to be a relatively under-researched area. Thus, taking into account the tentative findings of Good and Power (1976) that classrooms might contain, typically, five pupil stereotype groups, each requiring a particular learning provision, further research along the following lines seems desirable;

1. the collection of more data on pupils' perceptions of their physics classrooms,
2. a comparison of pupils' perceptions of reality with the style of teaching they would prefer, and
3. an investigation of the association of preference 'match' with attitudes and achievement in physics, according to pupil stereotype grouping.

2.7. SUBJECT CHOICE AT G.C.E. A-LEVEL

Choosing subjects for A-level study is influenced by both attitudinal and attainment factors. This conclusion appears in a major review of the developing patterns of sixth-form study conducted by Lewis, D. (1972). Wilkinson (1967) has shown that subject enjoyment at the O-level stage is an important pre-requisite for further study in the sixth-form. In an extensive survey of Northumberland sixth-formers, Selkirk (1972) found that 78 percent of these students had chosen their A-level subjects 'freely', without external constraints such as career and university entrance requirements. However, he did report that for students of physics, as high a proportion as 38 per cent were studying the subject because they had to rather than because of some intrinsic subject satisfaction.

The results of a survey of physics students in five schools conducted by Pell (1975) supported the hypothesis that,

1. when given a free choice, fifth-form O-level physics pupils choose to study those A-level subjects which they most enjoy, and
2. when faced with restrictions on this choice, governed by career and practical limitations, these pupils choose a different pattern of A-level subjects.

In particular, Pell's survey showed that the 'mixed' A-level subject grouping of Science/Arts/Humanities suffered when the pupils choice was 'bound' (i.e. subject to some external constraint) rather than 'free'. As this shift occurred, for both boys and girls, it was the science subject grouping which enhanced its 'popularity'.

The existence of a group of students in science sixth-forms, who have been 'pressed' into studying a full A-level science subject option, has important implications for curriculum analysis and innovation. Several writers, including Selkirk, Pell, and Duckworth and Entwistle (1974b), have suggested that the expansion of sixth form education over the last twenty years, in increasing the range of available A-level subjects, has permitted a greater proportion of students to exercise a free, more personally valid choice of subjects. The consequence of this is that, overall, a smaller proportion of students opt for the classical science subject combination, which appears as a 'swing from science'. (See Section 1.3 earlier).

A particularly interesting aspect of the surveys of Selkirk and Pell is that both researchers detected the significant 'bound' science and physics groupings in the first half of the decade of the nineteen seventies, when, as figure 1.2.1 (p. 6) shows, the 'swing from physics' on a national scale was showing little sign of being arrested. However, in the second half of the decade, the swing appears to be stabilising which suggests that the proportion of students making 'bound' choices of physics might now have settled at some lower level. The phenomenon of the 'bound' choice is unlikely to disappear completely, however, some students are almost certain to find themselves choosing subjects because these have been pre-determined by their free choice of others.

Turning to specific reasons for choosing A-level physics, several studies both in the U.K. and the U.S.A. have shown that the major sciences and physics in particular are studied to an advanced standard at pre-university level for utilitarian career purposes and as 'qualifying' subjects rather than because of intrinsic subject interest. A survey for the Department of Education and Science (D.E.S.) conducted by Gordon and Williams (1977) showed that subject enjoyment was easily the most important reason for the A-level choice of a subject, except in the sciences where the career reason dominated. These findings supported Duckworth's earlier grammar school survey (Duckworth, 1972). With a small sample of public school boys, Hockey and McKim (1968) obtained similar results: English literature was chosen mostly for interest reasons, physics mainly for career reasons. Reference has already been made to Selkirk's study, and in the U.S., Brown and Elliott (1973) found as high a proportion as 80% of Californian college students taking physics just because it was needed in their main course: only 13% were studying the subject because of intrinsic interest.

In his study, Pell (1975) used check-lists of possible reasons to find why two groups of students, those choosing and those rejecting A-level physics, had made their decisions. For over half of those choosing physics, the main reason was career needs: for about one-sixth, it was intrinsic interest in the O-level physics course (perceptions of the A-level course were insignificant). Those rejecting physics did so mainly because of the perception of a difficult and uninteresting O-level course. The perceived mathematical nature of the A-level physics course, and, especially for girls, a perception of unattractive A-level physics teaching methods, were the strongest of the secondary reasons.

The weight of the research evidence on the choice of physics at G.C.E. A-level strongly suggests that the apparent popularity of physics in numerical terms in relation to other A-level subjects (D.E.S., 1977) is mostly a function of extrinsic rather than intrinsic motivation to study the subject. Whether such a state of affairs is desirable or not, this conclusion raises the question of the degree to which new courses like the Nuffield Advanced Physics Project (Lewis,J.1972) and the Harvard Physics Project, both of which aim to cultivate an intrinsic interest in physics, can be successful with those pupils who at the age of 16 years choose physics for other reasons than enjoyment and interest.

2.8. THE ATTITUDES AND BEHAVIOURS OF SCIENCE TEACHERS

In Section 1.6. some evidence was outlined, almost exclusively from the U.S.A.(Good et al., 1975) and Australia (Gardner, 1976) that teachers' behaviour in the classroom does influence pupils' progress in both affective and cognitive terms. Good et al. point out that, although research has not yet linked teacher behaviour and pupil achievement in a causative way, consistent positive results across different studies by different investigators show that pupils learn best when taught by a teacher

> "... who is determined to teach the content that he is supposed to teach, who is well prepared and organised in his instructional behaviour, who is enthusiastic and

> skilled in motivating students, and who encourages the students to become involved in an active way in the learning process, is more likely to be successful than a teacher who lacks one or more of these characteristics."
> (op.cit. p.59)

Such a teacher, they go on to say, will employ variability in method of instruction and instructional media. He will question the pupils rather than lecture to them; use variability in his questioning style, and refrain from consistent criticism of his pupils. Good et al. acknowledge that their characteristics of effective teaching have been obtained from correlation studies, but the consistency and face-validity of the relationships strongly suggest that they are real. They recommend that future studies should include these teacher characteristics in their designs.

The desirable teaching profile identified by Good et al. is a general one but Gardner's study of students' attitudes on the P.S.S.C. physics course confirms its suitability in the science classroom. The pupil perceived teaching behaviour most effective at arresting declining enjoyment in physics was intellectual ('well prepared'), enthusiastic and achievement pressing (see Section 2.6). Even so, Gardner found that such behaviour did not suit all students; the low achievers disliked this method although the high achievers responded to it. Good and Powers' attempt to identify specific pupil-types within a classroom (Section 1.6) supports the differential effect of teacher behaviour that Gardner discussed. Indeed, the existence of pupil-types suggests that optimum teacher behaviour expressed by Good et al. is generally true for most pupil-types for most of the time, but that it is unlikely to be a valid method for all pupil-types under all circumstances (Good et al., p.84).

According to Good and Power's hypothesis, teachers of similar characteristics would be expected to bring about different learning and attitudinal outcomes in classes of different typological structure. The two researchers use their hypothesis to explain why some earlier studies provided equivocal results: the class itself is too coarse a unit for investigation. This is possibly the reason why earlier research on teaching behaviour in the nineteen sixties showed that, generally, the links between teacher characteristics and student learning are contradictory and inconsistent (Rothman, 1969). The H.P.P. evaluation included a number of attempts to identify optimum teaching behaviours, but with only mixed success. The main H.P.P. results were:

1. teacher attitudes do not affect pupil cognitive outcomes (Rothman, 1969);
2. teacher experience and physics education training do not affect pupil achievement or attitudes (Rothman et al., 1969);
3. the time spent teaching a topic does not affect achievement and is independent of average student ability (Welch and Bridgham, 1968);
4. interest in physics is improved when teachers are aggressive and dominate their classes (Rothman

et al., 1969);

5. students taught by experienced, well qualified teachers gain most in achievement (Rothman, 1969) - which appears to contradict finding (2);

6. teacher attitudes affect students' attitudes with students losing interest when taught by a teacher convinced of the importance of learning physics (Rothman, 1969), and

7. teacher personality does affect pupil attitudes and achievement but as the key personality variable is teacher hetereosexuality, interpretation is rather difficult. (Rothman et al., 1969).

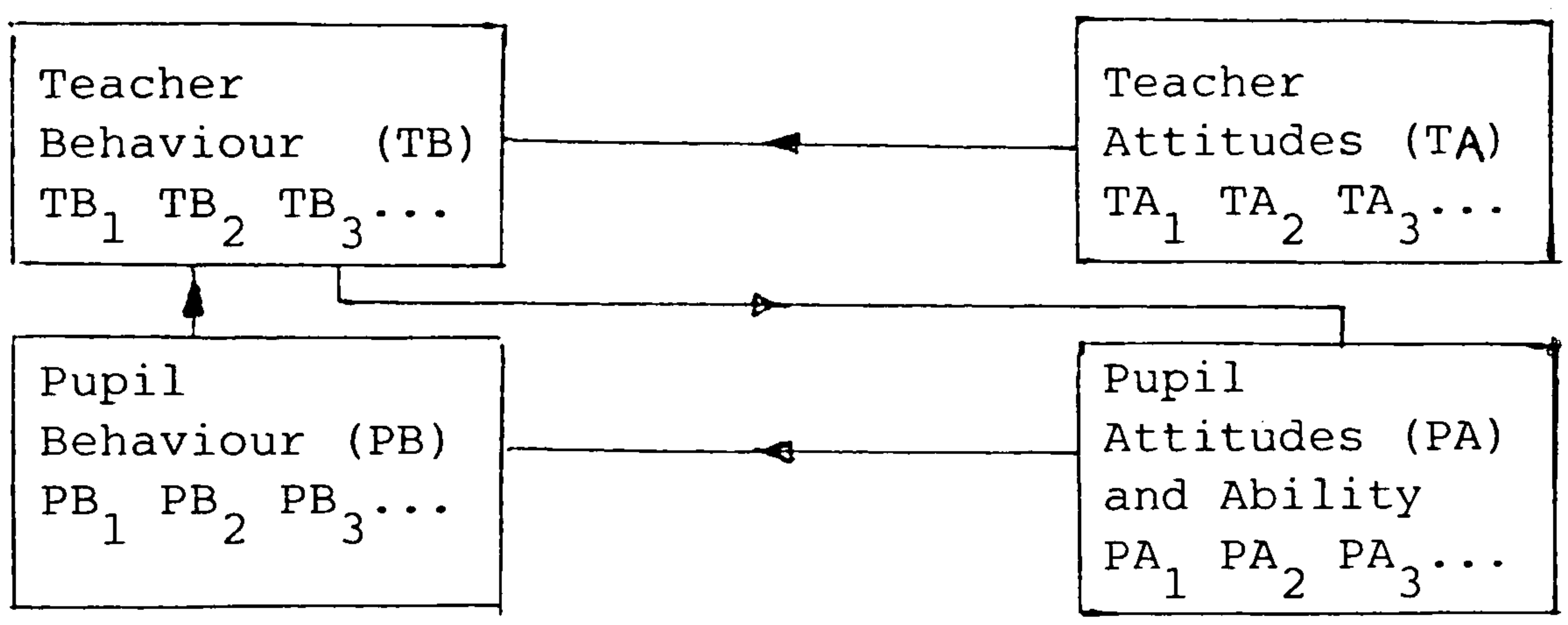
These findings are not conclusive but they do define those areas of teacher behaviour which influence pupil outcomes. Teacher personality and attitudes do have an effect and join those methodological and organisational aspects of perceived teacher behaviour (Section 2.6) is determining successful learning.

The relatively new techniques of statistical cluster analysis (Everitt, 1974) allows individuals with similar characteristics to be identified and grouped together to form a cluster. Individuals from different clusters are not alike. This procedure is more likely to correspond to reality than, for instance,a correlational approach (Entwistle et al., 1971). Brennan (1972) has compared the cluster classification procedure with other techniques. He remarks that there is virtually no knowledge of the typological structure that would underlie a sample of teachers. Before teaching effectiveness can be assessed 'natural types ' of teachers will have to be identified.

Some classification of the complex web of teacher-pupil interactions in the classroom environment is given by figure 2.8.1.

FIGURE 2.8.1.

INTERACTING CLASSROOM DIMENSIONS



Each dimension comprises a number of behaviour or attitudinal sub-dimensions such as TB_1, TB_2, TA_1, etc. By typological or factor analytical research, measures of some of these subdimensions can be obtained. Eggleston et al. (1976), for instance measured pupil attitudes and abilities, then by classroom observation made inferences about the influence of the perceived teaching style.

Several feedback loops may exist within the model of figure 2.8.1 in addition to the one shown, although there is some evidence that teaching behaviour and teacher attitudes respond only slowly to changing circumstances (Eggleston and Dreyfus, 1977). Good et al. (1975) remark:

> "With experience, all teachers develop habitual styles and teaching patterns but they do not quickly and easily change unless motivated to do so."
>
> (op.cit.. p.29)

The initial acquisition of attitudes and behaviour styles appears to owe much to the teacher's own experience of how he or she was taught (Mansell, 1974), although it is reasonable to expect teacher education to have a moderating if not formative influence. Eggleston and Dreyfus found remarkably little difference between the behaviours of physics teachers in training and experienced teachers, with both displaying the questioning, problem-solving approach. This suggests that there is a recognisable 'folk-lore' or craft in physics education, at least, which young teachers have assimulated, perhaps even before their professional training has begun.

Taylor et al. (1970a, and 1970b), have attempted to measure the attitudes of science teachers with a 106-item questionnaire. They identified eight factors (TA_1, TA_2,...TA_8) which were recognisable as attributes of an effective science teacher. Unfortunately, the lack of any internal consistency measures for the eight sub-scales, together with an uncomfortable psychological allocation of some of the items has lessened the impact of this work. Nevertheless, it does mark a worthwhile beginning in the preparation of reliable teacher attitude scales.

The importance of teacher attitudes as determinants of teaching behaviour has been emphasised by several subsequent attempts to use the scales of Taylor et al., developed at the University of Birmingham, in research designs on teacher effectiveness. All these attempts have proved abortive.

1. Brown (1974) surveyed teachers of integrated science in Scotland, but, using just those items which most closely describe the eight factors, she was unable to find any meaningful structure. Explaining these results as possibly due to the centralised nature of curriculum development in Scotland, Brown suggested that the Birmingham study be replicated with another sample of English teachers.
2. In the Schools Council study of teaching styles and pupil learning (Eggleston et al., 1976), additional items were added to the Birmingham questionnaire but, again, factor analysis methods pointed towards no clear psychological structure (Galton, 1977).
3. Eggleston and Dreyfus used the original Birmingham questionnaire in their study of student science teachers but, like Brown, were unable to find any interpretable factors.

Taylor et al (1970a) found that science teachers tend to be authoritarian and subject centred. They suggest that such teachers will be most successful with 'striving' or 'conforming' pupils. These pupils readily accept authoritative teaching and are highly achievement oriented: they are seen as the 'natural' group from which A-level science recruitment was made in the nineteen sixties. Finding the science teachers rather socially insecure, Taylor et al. hypothesise that confidence and success in teaching is closely allied to their intellectual concern with the objective nature of their subject material. To make science more attractive, Taylor et al. propose that teachers be encouraged to modify their attitudes towards science subject matter, in particular to see science as an imaginative and creative activity having significant human implications.

In their factor analysis of teachers' attitudes to effective science teaching, Taylor et al. found that the 'subject matter' teaching style with its emphasis on factual knowledge retained for tests and examinations received the lowest rating despite the subject-centred approach of science teachers, generally. Teaching styles receiving the highest ratings were those which are pupil centred. However, none of the styles identified seem capable of promising

> "... to produce an education in science... to fit the pupil to grapple creatively with scientific ideas."
> (op.cit.,p.59)

Taylor et al. conclude that teachers have not yet come to grips with the varied elements which contribute to science teaching, and as yet are unable to balance the pupil-centred with the subject-centred approach while mediating this with a re-appraisal of the nature of science.

There is evidence that teachers' classroom behaviour is consistent with their expressed attitudes (Stern, 1963). Early research on teacher behaviour originated in the U.S.A.and has been reviewed by Wallen and Travers

(1963). Studies, mainly from the nineteen fifties, were mostly concerned with the two broad communication styles of the 'lecture' and the 'discussion'. This broad classification compares well with Wankowski's 'one-way' and 'two-way' styles in Section 2.6. Attempts to show the superiority of the lecture over the discussion, or vice-versa, usually proved abortive, although the lecture approach is probably slightly better for factual mastery and the discussion method is slightly better for the development of thinking skills and problem-solving (Stern, 1963 and Gagné, 1970). A measure of support for these views is given by Houston (1975) who investigated the cognitive outcomes of physics classes in Scotland taught by one of three styles. These were

(a) a direct, expository, teacher-centred method ('traditional')

(b) an indirect, open-ended, pupil-centred method (the style envisaged by the new Nuffield curricula Section 1.3), and

(c) a style intermediate between (a) and (b).

Houston concluded that the direct, 'lecture' approach was more consistently related to success in answering questions testing routine skills and basic fundamentals. The open-ended method led to erratic performance. For the higher cognitive thinking skills, Houston suggested that a variety of methods should be employed.

The international survey of science education (Comber and Keeves, 1973) showed that in some countries, notably in India and New Zealand, where the 'drill' or direct method is widely employed, the use of this method correlates positively with achievement. Sardar (1977) reports that teacher- and book-centred learning is strongly characteristic of the Muslim approach to science education. The essence of this method, Sardar points out in perhaps a definitive phrase, is 'science as a revealed truth'. This is not to say that all expository , teacher-centred behaviour leads to passive rote learning, but Shulman and Tamir (1973) in a more recent review of U.S. practice report that such a style was adopted in a large sample of high school physics classes for between 80% and 90% of the time for which they were observed. Power (1977), in a review of science classroom interaction studies, points out that such classroom domination by the teacher is not uncommon and that pupils rarely ask questions or initiate activities. Power goes on to remark that structure in science lessons is essential for many pupils, however, if they are to acquire meaningful lesson content. Entwistle (1978b)takes this point further, and suggests that the structure of scientific knowledge and the nature of learning means the initial rote learning of factual content is essential for all pupils before the later skills of problem-solving are encouraged.

With the indirect, open-ended teaching method finding little support amongst researchers and reviewers (Houston, Ormerod and Duckworth, 1975, Power), and the evidence in favour of at least a proportion of classroom time being allocated to 'traditional' expository methods, it is reasonable to propose that the 'intermediate' style of guided discovery learning with appropriate pupil experimental work and self-initiated activities be considered as a possible optimum style (Gagné, 1970). Unfortunately, positive results from research are sparse. In an early review, Watson (1963) concluded that there was no firm evidence of the worth of laboratory work in science. Schefler (1965) found that learning biology 'by experiment' produced no significant differences when compared with 'traditional' teaching. He concluded that, at least, the method was not harmful (!). The results of the international science education survey (Comber and Keeves) gave no clear picture on the worth of experimental, laboratory learning although achievement was found to be higher in schools with laboratory assistance. There was some evidence that in lower secondary education, controlled (i.e. 'guided') practical work was superior to an informal approach. Shulman and Tamir (1973) suggest that for some teachers and pupils a non-practical approach may be an advantage but they admit clear evidence is simply not available. They feel that the effectiveness of practical work depends upon the stage during the learning process at which it is introduced.

The most systematic investigation of science teacher behaviour has been conducted by the Schools Council team (Eggleston et al., 1976). A highly structured observation schedule was used to observe science teachers of 'Nuffield' biology, chemistry and physics. One teaching style clearly identified was the teacher-centred, fact-acquiring expository (or 'traditional) approach. This was the style used by most biology teachers despite the apparently contradictory demands of the Nuffield course aims. In chemistry and physics, the 'intermediate' style, with a strong teacher guidance element accompanied by a problem-solving questioning approach to theory and practical work, was dominant. Indeed, in physics, this method was extremely popular. The third style, a pupil-centred, inquiry method was used relatively infrequently in physics and in about one-quarter of the classes in biology and chemistry. Attitude and attainment gains were compared across the three identified styles. Attitude changes were independent of style for the most part, although in physics: the 'traditional' approach was least successful; the 'intermediate' guided-discovery method was more successful with high ability boys, and the pupil-centred method seemed best for boys of lower ability. Attainment findings were generally inconclusive, but included

1. in biology, the 'intermediate', guided-discovery method was superior for the lower ability intellectual skills;
2. in biology, the pupil-centred style was better for the higher abilities, and
3. in physics, the 'intermediate', guided-discovery method was superior.

The Schools Council team conclude that the factual, expository approach has little to recommend it. The teacher-centred, problem-solving ('intermediate') style is to be preferred, for the most part, but under some conditions (for learners with initially poor attitudes, for instance) the pupil-centred style should be considered.

2.9. MULTI-VARIABLE STATISTICAL ANALYSIS

It is traditional in multi-variable research studies to seek associations by means of correlation analyses (for example, Walberg, 1969b, Entwistle, 1974, Brown, 1976). More sophisticated techniques which are based upon the correlation procedure are

a) factor analysis

b) multiple regression analysis

c) residual change analysis

d) discriminant function analysis.

The advent of high speed, large capacity computing systems has permitted the development of packages of programs, which make the otherwise weighty computations involved in these procedures now a trivial task. Packages commonly available include the Statistical Package for the Social Sciences (S.P.S.S.), (Nie et al., 1975) and Programmed Methods for Multivariate Data (P.M.M.D., Youngman, 1975). A further powerful analytical technique which is now more readily available is that of

e) cluster analysis.

a) FACTOR ANALYSIS

Factor analysis uses correlations between variables to identify those which have a common property. This property is called a factor and receives, to varying degrees, contributions from all the variables in the analysis. Simple correlations between the factor and the variable, which are expressed by a factor structure matrix, allow the factor to be described in psychological terms. A score on the factor can be computed either from all the contributions of all the variables, or from a summation of the scores of those variables which correlate most highly with the factor. Youngman (1979), in a review of statistical procedures,suggests that variables with correlation coefficients in excess of 0.3 be used in such a summation.

Each factor statistically extracted is able to account for a certain proportion of the total variance of the variable scores. This proportion is expressed by the eigenvalue of the factor, which for practical analysis should be greater than 1.0 (Youngman). Thus, in a principal components factorisation, statistical factors are isolated which account for as much of the total variance as possible while being independent of each other. In other words, the axes which define the directions of the factors are at right angles to each other. Whereas in, perhaps, clinical psychological terms it is desirable to use factors that are orthogonal, and Eysenck's personality dimensions of extraversion and introversion (Section 2.4) are typical of this, attitudinal analysis might reasonably be expected to identify factors that show substantial inter-correlation. Most computer programs, such as the S.P.S.S. and P.M.M.D., are able to rotate the factor axes to redistribute the variance in the scores into as few factors as possible. This procedure can be done either by keeping the factors axes at right angles (a varimax rotation) or, as is more appropriate to attitudinal data (Youngman, 1979) by allowing the factor axes to settle with some other angle between them in an oblique rotation.

The factor analytic approach to the understanding of an educational problem passes through the following stages:

a) data reduction by factor identification,

b) computation of factor scale scores,

c) reliability and validity tests on the factor scales, and

d) breakdown of the scale scores according to the research design criteria and hypotheses.

The technique is clearly applicable to the development of attitude and personality scales, for example, the Science Attitude Questionnaire (Galton et al., 1975) and the Eysenck Personality Inventory (Eysenck and Eysenck, 1964). Major research studies which have employed factor analysis in a post-test development design include those of

1. Entwistle and Wilson (1977), who identified five factors associated with success and failure in higher education, but who then cautioned against the attempt to identify only <u>one</u> path towards success from the correlational analysis which indicates a severe limitation of the method.

2. Ben-Zvi et al. (1977), who found five factors

to describe the cognitive and affective abilities of 15 year-olds in science classrooms. The factor scores were compared for pupils choosing either the sciences or the humanities to show that the science choosers had the higher cognitive abilities.

3. Walberg (1967), who found five factors in the responses to a science activities inventory and compared factor scores for the boys and girls. This was part of the Harvard Project Physics evaluation (Section 2.4) but it is surprising to find that Walberg used an orthogonal factor analysis only and assumed no correlation between some apparently conceptually similar factors.

b) MULTIPLE REGRESSION ANALYSIS

The principle underlying multiple regression analysis is that it is possible to link a major criterion or dependent variable to other, independent predictor variables by means of a single linear equation. The relative contributions of the predictor variables to the regression equation are given by standardised coefficients called beta weights (Kim and Kohout, 1975a). Values for the criterion variable are calculated from the regression equation and, for each individual, are compared with the actual criterion score to yield an overall multiple correlation coefficient. In a step-wise iterative multiple regression approach, the independent variable which has the strongest association with the criterion is first identified. The program then selects a second independent variable, which when combined with the first in a simple linear equation produces the greatest increase in multiple correlation. The procedure is repeated with additional independent variables until the increase in multiple correlation coefficient becomes insignificant.

As long as the fundamental premise of multiple regression analysis is obeyed, that the characteristics of all individuals can be described by the same linear equation, the relative importance of the variables in a multivariate analysis is statistically revealed from a study at the beta weights in the equation. However, as Youngman (1979) points out, low beta weights do not always indicate lack of importance, especially if two or more of the independent variables are highly correlated, because after one of these has been included in the equation, relatively little variance in the criterion will remain to be explained by the others.

Youngman cautions against the use of multiple regression for small samples and for large numbers of variables. The method is likely to over-emphasise chance variations, which tends to make the interpretation of beta weights unreliable. The method is unsuitable if the number of independent variables is greater than the sample size.

Studies that have used multiple regression analysis include those of

1. Anderson and Walberg (1968) who, as part of the H.P.P. evaluation, investigated the relative strengths of classroom variables on achievement and attitudes in physics. Beta weights in the regression equation for achievement showed that informal, organised and socially homogeneous classes obtained the best results.
2. Entwistle et al. (1971b), who used beta weights to explain the relative contributions of motivation and personality variables to academic achievement in higher education. This analysis was repeated by Entwistle and Wilson (1977) for different areas of study, which revealed different patterns of beta weights.

These earlier studies report the beta weights for all the variables in a regression equation, whether the weights are significant or not. Given the uncertainty in the reliability of these regression coefficients, it seems prudent in multiple regression analysis to limit the regression equation to those variables which have statistically significant coefficients or weights only.

c) RESIDUAL CHANGE ANALYSIS

While it seems self-evident that the difference between pre-test and post-test scores on a variable will be a measure of the 'gain' on that variable, there is a considerable weight of opinion against the validity of such an approach, for example Lord (1963), Cronbach and Furby (1970), Good et al. (1975) and Youngman (1979). Those arguing against the use of raw change scores point out how, inevitably, low scorers on the pre-test measure tend to show high gains and vice-versa. Alternative change measures also draw criticism, as Youngman points out, but the most acceptable method, he suggests, is a method of residual change analysis with a range of covariate controls.

The method of residual change employs multiple regression with the post-test score as the criterion variable and the pre-test score as the predictor or independent variable. From this simple linear regression equation, a predicted post-test score is computed from a knowledge of the pre-test score. The predicted and the real post-test scores are then compared for each individual and the difference is the 'residual'. A positive residual score indicates a real post-test score above the predicted value. For the complete sample, the mean residual score will be zero but some individuals will do worse and some will do better than predicted. As the predicted scores take into account the initial pre-test scores (a raw score gain analysis does <u>not</u>), it is usual to say that the pre-test differences have been controlled for or partialled out.

Although a simple residual analysis eliminates differences on the initial pre-test measure, the criterion variable and hence the residual itself might still be influenced by an uncontrolled association with some other independent variable. In multi-variable research, several independent variables might be significantly correlated with the criterion: these variables become covariates in the analysis and can be controlled for in one of two ways. The covariates can be used as independent variables in reconstructing the multiple regression equation with the post-test as criterion and the pre-test as one of what is now a number of predictor variables: the residuals are then used as before (Youngman, 1979). Alternatively, a conventional analysis of variance program can be run on the criterion variable scores which have been corrected for co-variate variation (Kim and Kohout, 1975b).

Major studies which have used residual gain analysis include those of

1. Walberg and Anderson (1968), who measured achievement and interest in physics as part of the H.P.P. evaluation. The residual interest gain was found to be correlated with an organised classroom environment and the residual achievement gain with a socially homogeneous, achievement-goal directed classroom. There was no attempt made in this study to use covariate controls.
2. Welch and Bridgham (1968), who measured the gain in physics achievement and related it to teaching duration as part of the H.P.P.

evaluation. There was no significant association between the 'corrected' post-test scores and the time spent. Covariate controls were not used.

3. Bennett (1976), who measured the gain in achievement amongst primary school pupils and related it to teaching style, but without the use of covariate controls.

4. Gardner (1976), who measured the change in attitude to physics using covariate controls in an analysis of variance design. He found that enjoyment was most likely to be maintained in classes where the pupils were achievement motivated, serious and intellectual and where the teachers were achievement-oriented, intellectually stimulating and well organised.

d) DISCRIMINANT FUNCTION ANALYSIS

Discriminant function analysis permits several linear equations to be constructed, comprising the research variables appropriately weighted by standardised coefficients. Each equation defines an orthogonal function which discriminates between groups of individuals. It is thus necessary to identify these groups before commencing the discriminant analysis. Once the variables which do not actually discriminate between groups have been rejected, those remaining are used to construct functions which produce a maximum separation of the groups in orthogonal directions (Klecka, 1975; Youngman, 1979). These discriminant functions can be described in psychological terms by those variables receiving the strongest weightings. In this way, it is possible to distinguish between groups of individuals by using just one or two particular sub-sets of the research variables rather than the whole range.

The effectiveness of the discriminant analysis is checked by a re-classification procedure in which the individuals are re-allocated to groups according to their scores on the discriminant functions. If the research variables and the composed functions can perfectly explain the differences between the original groups, then a 100% re-classification occurs. If, as is more likely, the variables cannot explain completely the group differences, then re-classification is less successful.

The relative strengths of the discriminating functions are expressed in terms of the proportion of the total variance in all the discriminating variables for which a function can account.

Studies employing discriminant function analysis are rather uncommon. Brennan (1972) used the technique to help distinguish between types of student in higher education. He points out that an additional advantage of the method is that it helps to clarify the structure of groups by displaying their composition graphically, with the axes defined by the two (or more) major discriminating functions. Hutchings et al. (1975) were able to distinguish between arts and science students in the upper sixth-form by reducing their range of research variables to cognitive and personality measures with the help of discriminant function analysis.

e) CLUSTER ANALYSIS

Reference has been made earlier to the criticism which can be made against the use of the correlation based techniques in multivariate analyses. Experience with the real world suggests that there is a variety of paths leading to success and failure, while the correlation methods even out these subtle differences and present a global pattern of relationships which might be true for only a few individuals. This is well illustrated by the results of the Entwistle and Wilson study of successful university students (Entwistle and Wilson, 1977).

> " Most successful students had <u>some</u> of the indicators of success, but very few scored on every measure which predicted high degree performance."
>
> (op.cit. p.122)

The answer appears to lie in the identification of types or clusters of individuals who score similarly on the research variables. Other clusters will display their own characteristic profiles of scores. By using a statistical technique which mirrors more exactly the outcomes of real human behaviour, a more valid interpretation of multivariate data is expected.

Brennan (1972) has made a substantial study of typological or cluster analysis. He points out that little use has been made of the technique in educational research but goes on to show its applicability in an extensive analysis of Entwistle's data on university students (Entwistle and Brennan, 1971). Brennan demonstrates that a combination of cluster and multiple regression analyses can act as a powerful and valid statistical tool. He shows that the criterion variable will regress differently on the independent, predictor variables for different clusters. An overall multiple correlation can be increased substantially by performing the multiple regression within each cluster after some similarity between the cluster members has been established.

The clustering program used by Brennan is now more readily available in the P.M.M.D. package (Youngman, 1975). Individuals are initially allocated at random to any one of up to, say, fifteen clusters. Mean standardised scores are computed for each research variable for each cluster and the profile of scores for each individual is compared with the cluster profile. Although this comparison can be achieved by a variety of statistics, Brennan (1971) and Youngman (1979) both recommend the 'error sum of squares' distance measure. Individuals are transferred from one group to another which shows a better profile match. The underlying principle is that there should be a minimum distance between the individuals of a group or cluster, but that, in effect, the clusters themselves should be widely spaced. The relocation scan is repeated a number of times until the composition of the clusters becomes stable and no further transfers of individuals occur. Each cluster is then defined in terms of those variables which show the most extreme mean scores.

The program continues by merging the two most similar clusters and repeating the previous procedure to relocate individuals. Another stable cluster solution is obtained. Successive repetitions of this procedure reduces the number of clusters eventually to just two. In deciding upon which particular cluster solution to take for further analysis, Brennan (1972) and Youngman (1975, 1979) suggest that the large increase in 'error distance' which occurs when two relatively dissimilar clusters are fused should draw attention to the solution which existed directly before the fusion.

Cluster analysis has been used in relatively few studies almost certainly because of the lack, until recently, of readily available programs. These few successful studies include those of

1. Entwistle and Brennan (1971), who, in an investigation previously referred to, identified twelve meaningful clusters of university students. They point out that cluster analysis does not yet lend itself to the precise testing of hypotheses generated from psychological theories but this might not be such a weakness.

2. Entwistle and Wilson (1977), assisted by Brennan, who identified clusters of university students within different subject areas and were able to determine the cognitive and attitudinal variables having the greatest effect upon degree class.
3. Eggleston et al. (1976), who identified a typology of science teaching styles (Section 2.8) by clustering the results of classroom observations.
4. Youngman (1979), who investigated the transfer of pupils from primary to secondary schools and identified seven recognisable pupil-types ranging from the strongly motivated and academic to the poorly motivated, unconcerned low-achieving. Youngman concludes that cluster analysis is ideally suited to investigate the nature of social situations which are described by multiple research variables.

CHAPTER 3

<u>THE RESEARCH PROBLEM AND HYPOTHESES</u>

3.1 CRYSTALLISING THE PROBLEM

The curriculum development method of Section 1.5 is now applied to shape the evidence of Chapter 2 into a series of clear research problems as testable hypotheses. Successful outcomes in physics classrooms can be measured in terms of

1. achievement in cognitive tests,
2. attitudes (enjoyment or interest),
3. the choice of physics when the pupil moves onto the next rung of the educational ladder.

By choosing the fifth-form of secondary education as the starting point for the research study, outcomes 1 and 3 are readily measured by the G.C.E. O-level examination and the take-up of A-level physics, respectively. Outcome 2, requiring measurement in the affective domain, remains to be monitored by gaining access to fifth-form classrooms.

Chapter 2 has indicated that outcomes are likely to be influenced by personality, study habits, motivation, classroom environment and sex variables. Successful fifth-form outcomes will permit the pupil to move through the sixth-form to reach the A-level rung on the ladder. Repeating the measurement of outcomes at the end of the sixth-form course will allow the effectiveness of A-level physics education to be assessed through the use of a pre-test/post-test design (see Chapter 4). By means of the appropriate statistical techniques (Section 2.9), the paths to success and failure in the sixth-form can be traced.

Hypotheses for fifth- and sixth-form pupils are generated, separately, from the Review of Earlier Work and appear below in Sections 3.2. to 3.4. In hypothesis formulation it is usual to treat the survey population as homogeneous within the limits of the stated criteria, for instance

'all boys will score higher than all girls...'

Evidence from Chapter 2 is that pupils and teachers might well be grouped in 'natural' clusters with each cluster member displaying similar characteristics but with members from different clusters showing different stereotype behaviour. Until 'natural' clusters have actually been identified, hypothesis formulation is hazardous (Entwistle and Brennan, 1971). However, if the hypotheses of Section 3.2. are taken as applicable to homogeneous samples, in the first instance, and tested as such, subsequent cluster analysis will be able to refine the hypothesis testing and possibly demonstrate validity for certain stereotype groups only. This might reasonably be considered a problem for solution during the next circuit of the curriculum research cycle.

3.2. HYPOTHESES FOR THE FIFTH-FORMERS

Fifth-form physics pupils

3.2a) find physics more difficult than other subjects,

3.2b) find physics less interesting than other subjects,

3.2c) prefer to learn in a varied environment where experiences include verbal, experimental and multi-media learning techniques provided under a strong teacher guidance element,

3.2d) if stable introverts, have the best study habits,

3.2e) if stable introvers, have the highest academic motivation,

3.2f) who have the highest achievement, as measured by the G.C.E. O-level grade,

i) display the strongest subject enjoyment,

ii) find the subject easiest,

iii) are introverted,

iv) show no specific anxiety characteristics,

v) have the strongest motivation,

vi) have the best study habits,

vii) are taught in a learning environment where pupil preference is matched by reality,

viii) are taught in a learning environment where varied experiences, including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element,

3.2g) show the strongest enjoyment when taught in a learning environment,

i) where pupil preference is matched by reality,

ii) where varied experiences including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element,

3.2h) when given a free choice of A-level subjects, choose to study those which they most enjoy,

3.2i) when faced with practical and career limitations, on the choice of A-level subjects, choose a pattern of subjects that differs from 3.2(h),

3.2j) if intending to study A-level physics,

i) are introverted,

ii) have high motivation,

iii) dislike arts subjects,

iv) choose physics because of career reasons,

v) have high Lie scores as measured by the Eysenck Personality Inventory,

vi) display higher achievement, as measured by the G.C.E. O-level/C.S.E. grade, than those rejecting A-level physics.

3.2k) if intending to reject physics in favour of other A-level subjects

i) do so because the O-level course was difficult,

ii) do so because the O-level course was uninteresting,

iii) display poorer attitudes towards O-level physics than those choosing the subject.

3.2l) whether boys or girls, show similar attitudinal responses and display similar choice/rejection patterns,

3.2m) comprise a number of recognisable stereotypes for whom achievement and enjoyment outcomes can be characteristically predicted.

3.3. HYPOTHESES FOR THE SIXTH-FORMERS

Sixth-form physics students,

3.3a) find the physics course

i) difficult,

ii) enjoyable,

iii) low in philosophical content,

iv) low in historical content,

v) low in social implications content,

3.3b) display a fall in enjoyment as the physics course progresses,

3.3c) ascribe the characteristics in 3.3(a) and 3.3(b) to their course according to the examination board controlling the syllabus,

3.3d) prefer to learn in a varied environment where experiences include verbal, experimental and multi-media learning techniques provided under a strong teacher guidance element,

3.3e) if anxious, display fear-of-failure motivation,

3.3f) if syllabus bound, display no particular study habits characteristic,

3.3g) who have the highest achievement, as measured by the G.C.E. A-level physics grade,

i) display the strongest subject enjoyment,

ii) find the subject easiest,

iii) have the strongest academic achievement motivation,

iv) have the strongest intrinsic motivation,

v) display no particular extrinsic motivation characteristics,

vi) have the lowest fear-of-failure motivation,

vii) display no particular syllabus-boundness characteristics,

viii) have the best study habits,

ix) are taught in a learning environment where student preference is matched by reality,

x) are taught in a learning environment where varied experiences, including verbal, experimental and multi-media learning techniques, are provided under a strong teacher guidance element,

3.3h) show the strongest enjoyment when taught in a learning environment

i) where preference is matched by reality,

ii) where varied experiences, including verbal, experimental and multi-media learning techniques, are provided under a strong teacher guidance element,

3.3i) whether boys or girls,show similar attitudinal relationships,

3.3j) comprise a number of recognisable stereotypes for whom achievement and enjoyment outcomes can be characteristically predicted.

3.4. HYPOTHESES FOR THE TEACHERS

Physics teachers responses to a form of the Effective Science Teaching Questionnaire

3.4a) reveal meaningful factors of behaviour,

3.4b) permit the establishment of a typology of teachers,

3.4c) permit mean class achievement and enjoyment outcomes to be related to teachers' preferred behaviours.

3.5. TESTING THE HYPOTHESES

Chapters 6, 7 and 9 describe the results for the teachers, fifth-formers and upper-sixth formers respectively. Each chapter is summarised by listing the relevant hypotheses, and their status after testing.

CHAPTER 4

THE RESEARCH DESIGN

4.1. THE OVERALL RESEARCH PLAN

The most practicable means of collecting data from a large sample of pupils is by pupil questionnaires (Nisbet and Entwistle, 1970). Validation checks are possible by means of (a) pupil interviews (b) teaching ratings of pupil behaviour and (c) observations of pupil-teacher interactions within the classroom.

Classes of pupils were to be monitored

1. during the fifth-form year,
2. at the beginning of the lower sixth-form year,
3. at the end of the upper sixth-form year.

Access to classes was constrained by the approach of external examinations for the fifth-formers and upper sixth-formers: all data collection had to be completed by the end of the second-term of the school year. The volume of the data base required from the fifth-form pupils was such that it was decided to space the collection across two terms with three relatively short questionnaires rather than impose a very lengthy questionnaire upon the pupils late in the school year. Sixth-form data was collected by just two questionnaires : one administered just after the start of the A-level course and the other around Easter in the second year.

The questionnaires were to be designed so that teachers could administer them to their classes with the minimum of organisational inconvenience. In the event, all teachers taking part in the survey were visited several times and advised in the use of the questionnaires. On occasions the author was able to administer the questionnaires directly to the pupils: on others, the teacher was allowed to administer the questionnaires when convenient, ensuring 'examination conditions' for their completion and assuring the pupils that their responses were confidential.

Classroom observations and pupil interviews were to be conducted in a sample of schools at times which were mutually convenient to the author and the teacher.

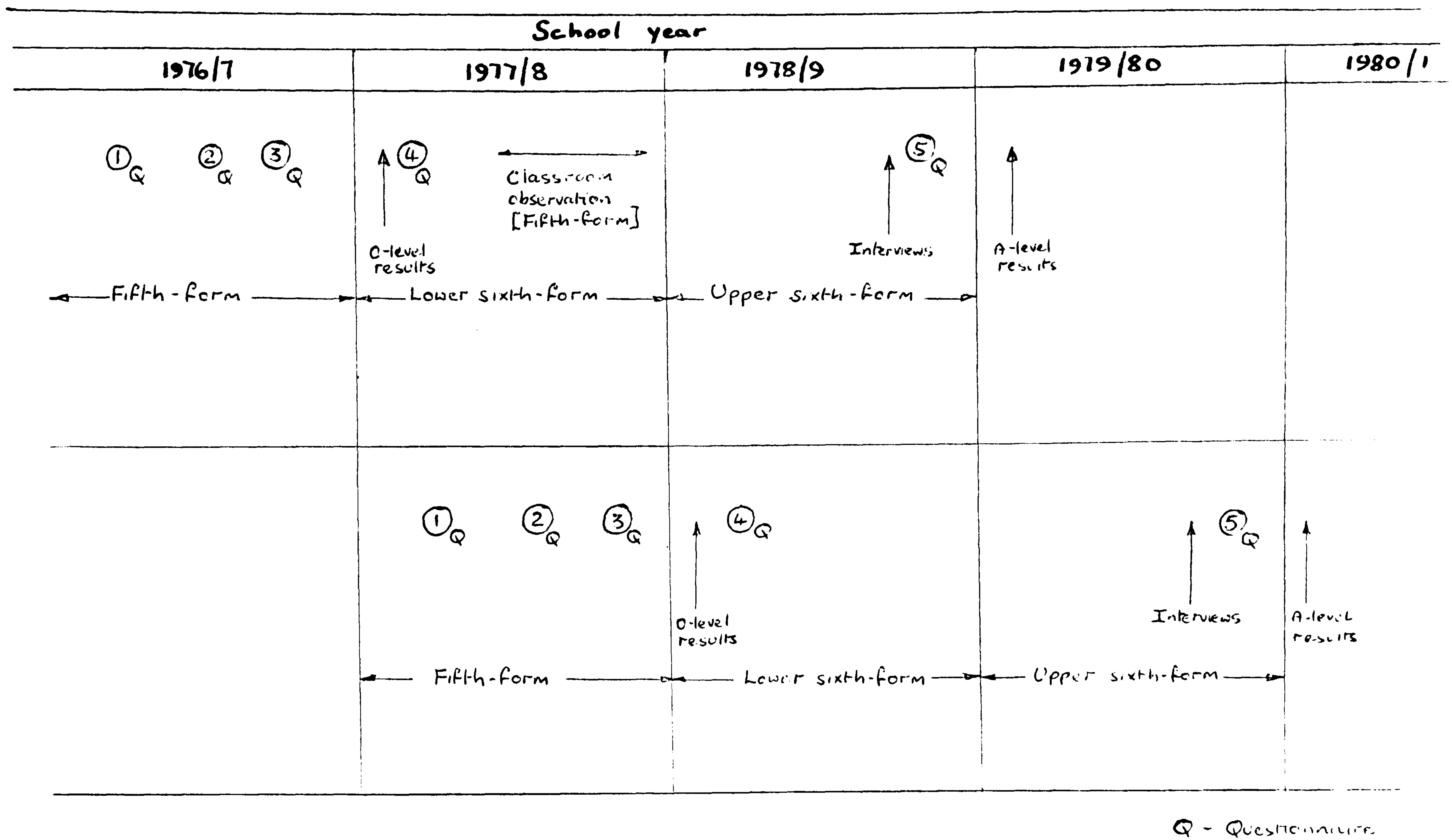
Teachers and their colleagues were to be invited to complete an Effective Science Teaching Questionnaire after one of the early school visits.

Figure 4.1.1 shows the overall research plan for the three-year longitudinal survey. Schools joining the project late in the first year contributed to the second phase of data collection running one year behind the first.

4.2. CONSTRUCTING THE QUESTIONNAIRES

4.2.1. Each pupil taking part in the project was given a personal letter explaining the purpose of the questionnaire survey (Appendix 4.2.1). In addition, each questionnaire unit (Appendices 4.2.2 to 4.2.6) was given an Introduction to describe the relevance of the information requested and to help to create a rapport

Figure 4.1.1 The time-scale of the research plan



with the respondents.

The design of the questionnaires followed from an earlier study conducted by the author (Pell, 1975) which, in effect, acted as a pilot questionnaire design exercise for the current survey.

Section A for each questionnaire comprised personal information questions, which allowed academic achievements, subjects studied, career intentions and examination motivation to be assessed.

4.2.2. THE FIFTH-FORM QUESTIONNAIRES

Apart from the common Section A of each questionnaire, the composition of the rest of each unit was determined as follows:

1. As hypotheses concerning subject choice at A-level and relative subject enjoyment were to be tested, the greatest validity would be obtained from responses as late in the fifth-year as possible. Appropriate scales (see Sections 5.5 , 5.6 and 5.7 of this Report) were thus included in the Unit 3 questionnaire.
2. Personality, motivation and study scales tend to require dichotomous responses (see Section 5.3). By including these measures together in one questionnaire unit (Unit 2), it was hoped that pupils would find it easier to complete the scales at the intended moderate

speed.

3. Enjoyment of physics lessons and preferred classroom organisation scales (see Sections 5.2 and 5.4) thus remained to appear on questionnaire Unit 1 as a particularly pertinent introduction to the survey.

The construction of the scales and details of pilot testing, where appropriate, appear in Chapter 5.

Questionnaire units 1 and 3 permitted pupils to amplify their attitudinal responses and choice reasons by means of a 'free-response' section.

4.2.3. THE SIXTH-FORM QUESTIONNAIRES

To measure a hypothesised attitude change over the sixth-form course, a pre-test/post-test design was adopted to measure course attitudes on the same scale (section D on the Unit 4 questionnaire, section B of the Unit 5 questionnaire). Details of the development of this scale appear in Section 5.9 of this Report.

The lower-sixth form questionnaire measured, retrospectively, subject choice and rejection reasons (sections B and C) and preferences for examination preparation method (section E). Further details of these scales appear in Sections 8.3 and 5.8 of this Report. A final section in the questionnaire was devoted to students' free responses.

In addition to subject attitudes, the upper-sixth-form questionnaire was to measure teaching method preferences (section C) and attitudes to study (section D) as required by the research hypotheses. The development of these scales is reported in Sections 5.11 and 5.10, respectively. Students' free responses were invited in the final part of the questionnaire.

4.2.4. OTHER DATA COLLECTION INSTRUMENTS

Teacher attitudes were to be measured with a modified form of the Effective Science Teaching Questionnaire. The development of this instrument is described in Section 5.12 (Appendix 5.12.1).

Classroom observation was to be performed with a modified form of the Science Teaching Observation Schedule (Section 5.4.4. and Appendix 5.4.3).

Student interviews were to be conducted with an interview schedule (Sections 5.11.3 , 9.5.12 , and Appendix 5.11.3).

4.3. COLLECTING THE SAMPLE

In September 1976, a letter describing the aims of the survey together with a summary of some earlier research findings (later published, Pell, 1977) was sent to 43 secondary schools in Northamptonshire, with the permission of the Chief Education Officer. Replies were obtained from 13 schools, all but two of which offered to contribute either as full members of the three year project, or, because of a lack of a developed sixth-form at that time, as 'pilot' schools for the testing of the attitude scales. Some 13 schools were willing to become full members.

Only one school was following the 'Nuffield' course in the fifth-form but, even here, the course reverted to 'traditional' in the sixth-form. As pointed out in Chapters 1 and 2, the newer curricula such as the Nuffield courses, introduce an important additional variable into research in science education, so it was with this particular need in view that an appeal was made through the regional organisation of the A.S.E. but with no success. However, three additional schools from outside Northamptonshire teaching 'traditional' physics were keen to become 'full-members' from September 1977.

As the first year of the project progressed, several teachers wished to start a comparative attitude study and asked if the questionnaires could be administered to their new fifth-formers in September 1977. The teachers and schools in this category, plus the three additional schools, thus defined the second phase sample, following on one year behind the first (figure 4.1.1).

Table 4.3.1 shows the class sizes, relative numbers of boys and girls, and G.C.E. examining boards. The classes shown in the table were drawn from mixed comprehensive schools apart from where indicated.

It is clear that the sample is in no way a random one, being severely limited by geographical

TABLE 4.3.1 'FULL-MEMBER' SURVEY CLASSES

Class	N (boys)	N (girls)	N (all)	G.C.E. examining board O-level	A-level
1	23	-	23	Oxford	Oxford
2	21	2	23	London	London
3	12	1	13	Oxford	Oxford
4	22	-	22	Oxford	Oxford
5	12	-	12	Oxford	Oxford
6	14	3	17	Oxford	London
7	20	5	25	Oxford	London
8	20	2	22	Oxford	London
9*	-	16	16	Nuffield	Oxford
10*	-	19	19	Oxford	Oxford
11*	24	-	24	Oxford	Oxford
12*	24	-	24	Oxford	Oxford
13*	17	-	17	Oxford	Oxford
14*	20	-	20	Oxford	Oxford
15*	22	-	22	Oxford	Oxford
16	7	5	12	Cambridge	Cambridge
17	6	6	12	Cambridge	Cambridge
18	3	5	8	Cambridge	Cambridge
19	16	9	25	A.E.B.	A.E.B.
20	32	7	39	A.E.B.	A.E.B.
21	9	4	13	Oxford	Oxford
22	16	9	25	Cambridge	Cambridge
23	18	8	26	Cambridge	Cambridge
24	6	17	23	London	London
25	16	1	17	London	London
26	11	10	21	London	London
27	22	3	25	London	London
28	17	4	21	London	London
29	17	-	17	London	London
30	12	3	15	London	London
31	26	3	29	A.E.B.	A.E.B.
32	4	1	5	Oxford	Oxford
33	24	4	28	J.M.B.	J.M.B.
34	24	5	29	J.M.B.	J.M.B.
35**	-	17	17	Oxford	Oxford
36**	-	16	16	Oxford	Oxford
37*	-	19	19	Oxford	Oxford
	537	204	741		

**Single-sex grammar school

*Single-sex comprehensive school

area and the practical difficulties of remaining in relatively close contact with 16 'full-member' schools and several 'pilot' schools.

4.4. HANDLING THE DATA

After completion, the responses were coded and transferred to punched cards. The data was then stored in computer files at the University of Leicester and the University of Manchester Regional Computer Centre in preparation for analysis by the appropriate statistical package (Section 2.9).

CHAPTER 5

DEVELOPING THE TESTS

5.1. INTRODUCTION

5.1.1. THE RESEARCH VARIABLES

In this chapter, the data gathered by the questionnaires is reduced to the various research variables necessary for testing the hypotheses of Chapter 3. Table 5.1.1. gives a brief description of the variables and refers to the section where each variable is explained in detail.

In addition to the variables in the table, the questionnaires provided a range of dichotomous data, which permitted scores on the other, continuous variables to be appropriately analysed. Not the least of these were the sex of the respondent and the choice or rejection of A-level physics. These variables are explained further as they are introduced in the main narrative.

5.1.2. ATTAINMENT CRITERIA

It is usual to treat G.C.E. examination grades as interval measures, converting them to simple numerical scales by scoring grade A as seven, grade B as six etc., to obtain a seven-point scale for the A-level examination for instance. The corresponding O-level examination scale would be a six-point one. Such an approach has been used by Choppin et al. (1973); Nuttall et al. (1974); Entwistle and Wilson (1977) and Collings (1978) amongst others.

The statistical criteria used to draw grade

TABLE 5.1.1. THE RESEARCH VARIABLES

Variable	Description	Reference section
1. Committed physicist 2. Enjoyment 3. Learning-by-experiment 4. Problem solving	Four subscales of an attitudes to physics scale (fifth-form)	5.2.
5. Physics identification	A composite of variables 1,2 & 4	5.2
6. Interesting teaching style		5.2.
7. Study habits 8. Motivation	Two sub-scale of a modified version of the Rowntree test (fifth-form)	5.3
9. Study orientation	A composite of variables 7 and 8	5.3
10. Study habits in physics 11. Motivation in physics	Versions of scales 7 and 8 weighted towards physics	5.3
12. Extraversion 13. Neuroticism 14. Lie	The three scales of the Eysenck Personality Inventory (fifth-form)	7.3
15. Varied/teaching-for understanding (preference)	Preference for a specific teaching/ learning style (fifth-form)	5.4
16. Varied/teaching-for understanding (experienced)	Pupils' perception of the teaching on scale 15 actually experienced in the classroom	5.4
17. Varied/teaching-for understanding mismatch	Difference between scores on scales 15 and 16	7.10
18. Classroom match	The degree of match between the pupil's preferred learning environment and reality (fifth-form)	7.4/7.8
19. Physics satisfaction	An extended interest score relative to other subjects (fifth-form)	5.5
20. Physics 'slog'	Measures the burden of studying physics relative to other subjects (fifth-form)	5.5
21. Enjoyment 22. Easiness	Attitudes to physics in the sixth-form	5.9
23. Historical 24. Prestigious 25. Social implications 26. Philosophical 27. Modern	Course ratings in the sixth-form	5.9

(continued)

28. Academic achievement motivation	S.S.R.C. scales of motivation and study habits in the sixth-form	5.10
29. Organised study habits		
30. Fear-of-failure		
31. Syllabus-boundness		
32. Extrinsic motivation		
33. Intrinsic motivation		
34. Planned, 'method' teaching (preference)	Preferred and experienced learning modes in the sixth-form	5.11
35. Planned 'method' teaching (experienced)		
36. Notemaking/syllabus coverage (preference)		
37. Notemaking/syllabus coverage (experienced)		
38. Pupil-initiatitive teaching (preference)		
39. Pupil-initiative teaching (experienced)		
40. Classroom match	The degree of match between the pupil's preferred learning environment and reality in the sixth-form	9.4.
41. O-level physics exam. motivation	Four-point rating scale (fifth-form)	7.10
42. A-level physics exam. motivation	Four-point rating scale (sixth-form)	7.10
43. O-level physics grade	Six-point scale	5.1
44. Number of O-level passes		7.8
45. A-level physics grade	Seven-point scale	5.1
46. A-level score	Mean A-level grade for all subjects	5.1
47. Processes of science	Seven subscales of the Effective Science Teaching Questionnaire (teachers)	5.12
48. Competent, exam-oriented		
49. Pupil-oriented		
50. Interest-in-science		
51. Learning-theory		
52. Planned, experimental lab.		
53. Disciplined, pupil relations		

See Appendix 5.1.1. for a full alphabetic list of all variables boundaries are reasonably well agreed (Hudson, 1973; Forrest, 1971) but the G.C.E. examinations are norm-referenced rather than criterion-referenced assessment systems, which means that pupils of similar ability in a subject can achieve different grades according to the examination board, especially as there is evidence that different cognitive critera are applied at the grade boundaries (J.M.B., 1966; Hewitt, 1967; Scott, 1975; Hecker and Wood, 1979). Taking into account the reliability of typical O-level examinations, Willmott and Nuttall (1975) conclude that the standard error in each grade awarded is about ±0.5 grade, which is also the typical error in the grades of the Certificate of Secondary Education (C.S.E.). A more recent reliability analysis by Murphy (1982) included A-level subjects and led him to agree that a comparable standard error was present in A-level grades too.

The error in examination grades strongly suggested that little would be gained in moving away from an equivalent score technique. Table 5.1.2. shows the grade equivalent scores. Some of the survey pupils were subsequently entered for the C.S.E. physics examination. Like G.C.E. O-level this has a six-point assessment scale (Hudson, (1973).

TABLE 5.1.2. CONVERSION FROM ASSESSMENT GRADES TO SCORES

G.C.E.				C.S.E.	
A-level		O-level			
Grade	Score	Grade	Score	Grade	Score
A	7	A	6	1	6
B	6	B	5	2	5
C	5	C	4	3	4
D	4	D*	3	4	3
E	3	E*	2	5	2
O*	2	U*	1	Un	1
F*	1				

*A 'fail' grade
C.S.E. grade 1 is equivalent to an O-level pass grade (Hudson, 1973)

5.1.3. CLASSIFYING CAREER INTENTIONS

Career intentions were monitored over the three year to permit the interpretation of variable scores where appropriate. A six-category classification due to Holland (1966) was adopted with a slight modification to allow distinctions to be drawn between pure and applied science (table 5.1.3.).

TABLE 5.1.3. OCCUPATIONAL CHOICE AREAS

Occupation area (Holland)	Occupation area (survey)	Examples
Realistic	Labourer/skilled tradesman	Mechanic, shop-assistant
	Engineering or applied science	Higher education entrant, pharmacist
Intellectual	Pure science (higher education)	Physicist, doctor
	Non-science (higher education)	Lawyer, accountant
Social	Social	Teacher, nurse
Conventional	Conventional	Office work, secretary
Enterprising	Enterprising	Manager, salesman
Artistic	Artistic	Writer, musician, journalist

5.2. FIFTH-FORM PHYSICS ENJOYMENT

5.2.1. MODIFICATION OF THE SCIENCE ATTITUDE QUESTIONNAIRE

The Science Attitude Questionnaire, originally developed by the N.F.E.R. (Chapter 2, Section 2.2.), was selected as satisfying the criteria of conciseness and reliability demanded by the overall research design of the present project. The amended version, used by the Schools Council team at the University of Leicester (Galton et al., 1975), was readily available and was prepared for use. Appendix 5.2.1A gives the allocation of the items to the five sub-scales of the modified attitude questionnaire. The reliabilities of the sub-scales obtained with physics pupils are also shown.

It is clear that the four items comprising sub-scale (v), 'the career scientists', are very closely related and that the relatively high internal consistency of this scale (0.80) might well be due to the similarity of these items. In psychological terms, it is difficult to separate the meanings of sub-scale (iii) 'the committed scientists' and sub-scale (v) 'the career scientists'. A reasonable solution, which satisfies both objections, is to combine sub-scales (iii) and (v), deleting all those items of similar meaning. This procedure also has the advantage of removing items, such as

8. My mother wants me to be a physicist ,

which Gardner suggests do not strictly reflect the pupil's interest.

Two items:

6. I do well in physics, ['the fun factor' - sub-scale (i)] and

14. Physics is just a load of technical terms that are hard to remember, ['the practical investigators' sub-scale (ii)]

could be judged to be ambiguous. Item 6 is criticsed by Gardner (1975a) as implying that performance in physics must reflect a positive interest, which is arguable. Item 14 is a double-barrelled item requiring just one response to two possible statements. These items can be reworded as

6. Physics lessons give me a feeling of satisfaction,

and 14. Physics is just a load of technical terms.

Item 26,

Working in the physics laboratory is fun

could gain in sophistication, while possibly transferring from 'the practical investigators' to 'the concrete physicists' [sub-scale (iv), the one with the lowest reliability] by changing the wording of the item to

26. I am happy when working with equipment in the physics laboratory

These modifications resulted in a reduced 27-item scale to which a final statement

28. The methods used by the physics teacher are interesting in themselves

was added. The purpose of this was to measure the pupil's attitude towards the physics teacher's means of communication.

A favourable rating of this item might be either an attribute of the 'fun-factor' or, alternatively, part of another dimension of the learning process according to the role the pupil sees the teacher playing. For instance, if the teacher is merely expected to be a source of factual knowledge, the response to item 28 is likely to be irrelevant and the item would show little loading on any of the four factor sub-scales. However, should the teacher's role be seen as more expansive in creating an environment in which higher order thinking skills are to be developed, then the response to item 28 should be positive because of the motivation to learning induced by an enjoyable teaching style (Ausubel, 1968).

While it might be easy to allocate the modified or new items to one or more of the four remaining sub-scales, a complete re-factorisation is more properly in order, even if only to confirm the invariance of the original factors. Should a separate 'teacher factor' emerge after the addition of item 28, then this could be incorporated in the later multi-variable investigation. The full scale appears in Appendix 5.2.1B.

5.2.2. USING THE MODIFIED SCALE

Data was obtained from 37 classes in 16 schools: a total of 741 students of mean age 15 years 11 months. The questionnaires were completed during normal physics lessons under examination conditions.

5.2.3. FACTOR ANALYSING THE RESPONSES

The responses to the 28 items were scored from 1 to 5 on the five point scales with the highest score indicating the most favourable attitude.

A principal factor analysis was performed on the 28 item scores, which produced five factors with eigenvalues great than unity accounting for 55 per cent of the total variance. The variance was then redistributed amongst the five factors and a varimax rotation of the factor axes performed. The five factors were identified by the items that load most strongly on them (table 5.2.1.).

Factor scores were obtained by summing the scores on those items that loaded most strongly on each factor. At this stage, high correlations were found between 'committed physicist', 'physics enjoyment' and 'physics as problem-solving', which strongly suggested that the varimax rotation analysis was inappropriate as this process maintains the factor axes at right angles to each other, that is, it assumes zero factor correlation. Thus, the method of oblique rotation (section 2.9) was used to clarify the five-factor solution.

Although the oblique rotation caused changes in the item loadings on the factors, the general pattern remained unchanged. The 'teacher' factor 4 still appeared to be associated with very few items, yet it was quite distinct from 'enjoyment' factor 2. (Any attempt to merge item 28 with the enjoyment factor by restricting the oblique analysis to four factors causedthe distinction

TABLE 5.2.1. FIRST DEFINITION OF THE FIVE FACTORS

Factor	1	2	3	4	5
The two items that load most strongly on the factor. (Correlation between item and factor in parentheses.)	4. I like to talk with people about new discoveries in physics (0.67) 11. I should like to belong (or I like belonging) to a physics club (0.68)	1. I enjoy physics lessons more than other lessons (0.76) 10. I would enjoy school more if there were no physics lessons (reversed meaning) (0.67)	17. I would much rather do experiments in physics than read about them (0.72) 18. I would rather do a physics experiment than listen to a lecture on the same topic (0.65)	28. The methods used by the physics teacher are interesting in themselves (0.55) 27. Physics experiments demonstrated by teachers are more interesting than the ones you do yourself (reversed meaning) (0.30)	19. I want to learn for myself why physics experiments turn out the way they do (0.30) 23. Trying to solve a physics problem is interesting (0.23)
Factor Description	Committed Physicist	Physics Enjoyment	Learning by Experiment	Teacher as leader	Physics as a problem-solving activity
Percentage of variance accounted for	68.2	17.2	6.4	4.6	3.6
Number of items provisionally allocated to factor scale	8	9	5	2	4

TABLE 5.2.2. SECOND DEFINITION OF THE FIVE FACTORS

Factor	1	2	3	4	5
The two items that load most strongly on the factor Correlation between item and factor in parentheses	11. I should like to belong (or I like belonging) to a physics club (0.79) 6. I would like to be given a physics book or a piece of equipment (0.72)	10. I would enjoy school more if there were no physics lessons (meaning reversed) (0.70) 1. I enjoy physics lessons more than other lessons (0.67)	17. I would much rather do experiments in physics than read about them. (0.72) 18. I would rather do a physics experiment than listen to a lecture on the same topic (0.63)	28. The methods used by the physics teacher are interesting in themselves (0.62)	19. I want to learn for myself why physics experiments turn out the way they do (0.35) 20. It is fun to guess the outcome of physics experiments (0.34)
Factor description	Committed physicist	Physics enjoyment	Learning by experiment		Physics as a problem-solving activity
Percentage of variance accounted for	68.2	17.2	6.4	4.6	3.6
Number of items allocated to factor scale	7	9	6		5

between the other factors to blur.) However, if item 27 (table 5.2.1.) is transferred to the factor 3 scale with which it correlates at 0.40, this scale of 'learning by experiment' becomes one of six items, and then the 'teacher' factor 4 is isolated as just item 28.

Table 5.2.2. summarises the analysis at this point.

Scores on each of the four factor scales remaining were calculated by summing the scores on the items most highly loaded on that factor. Where an item was loaded highly on more than one factor, it was allocated to that scale with which it showed the greatest conceptual agreement: this was not necessarily the scale with which the item showed the greatest statistical affinity.

The variance of each factor score was then compared with the sum of the variances of the individual item scores making up that factor score by means of the Cronbach Alpha coefficient. This gave the internal consistences r of each scale score shown in table 5.2.3.

TABLE 5.2.3. SCALE RELIABILITIES

Present version (N = 741)			Schools Council version (N = 844)			Both versions
Scale	r	Number of items	Scale	r	Number of items	Number of shared items
Committed physicist	0.84	7	(iii)	0.81	6	6
Enjoyment	0.88	9	(i)	0.82	7	6
Learning by experiment	0.71	6	(iv)	0.67	5	5
Problem-solving	0.71	5	(ii)	0.79	8	5

The composition of the scales is clear from the correlation table 5.2.4. Where an item is normally included when calculating a factor scale score, it is omitted from the scale score summation when the correlation coefficient between the item score and the total scale score is computed.

TABLE 5.2.4. ITEM-SCALE CORRELATIONS

ITEM	Correlation between item score and factor scale score for			
	Committed physicist	Enjoyment	Learning by experiment	Problem-solving
1	0.58	*0.74	0.02	0.45
2	0.4C	*0.49	0.13	0.34
3	0.43	*0.51	-0.02	0.40
4	*0.62	0.50	0.05	0.54
5	0.63	*0.65	-0.02	0.52
6	*0.66	0.65	0.11	0.58
7	*0.47	0.45	0.02	0.40
8	*0.63	0.59	0.04	0.45
9	0.60	*0.72	-0.01	0.50
10	0.62	*0.72	-0.01	0.49
11	*0.70	0.61	0.07	0.57
12	0.42	*0.51	-0.04	0.37
13	*0.62	0.54	0.07	0.54
14	*0.50	0.40	0.01	0.40
15	0.57	*0.61	0.05	0.46
16	0.48	*0.60	-0.04	0.40
17	-0.03	-0.05	*0.58	0.06
18	-0.12	-0.11	*0.50	-0.01
19	0.50	0.41	0.28	*0.50
20	0.37	0.30	0.21	*0.39
21	0.15	0.05	*0.44	0.21
22	0.46	0.40	*0.37	0.49
23	0.55	0.59	0.01	*0.56
24	0.34	0.29	0.17	*0.40
25	0.55	0.48	0.03	*0.48
26	-0.08	-0.13	*0.42	0.00
27	-0.05	-0.07	*0.34	0.05
28	0.25	0.35	-0.07	0.27

*indicates scale to which item is allocated

A correlation of 0.07 is significantly different from zero at the 5% level, N = 741.

5.2.4. THE VALIDITY OF THE SUB-SCALES

The validity of the sub-scales was established by dividing each attitude score at the mean and allocating each pupil to either the 'low' or the 'high' category. These groupings were then compared with those drawn from independent measures of the four criteria.

(a) Validity of the committed physicist scale

The pupils were asked to state their intended career area. Those choosing a pure or applied science were identified.

TABLE 5.2.5. 'COMMITTED PHYSICIST' VALIDITY

Committed physicist score	Career Area	
	Science	Non-science
High	172	141
Low	74	268

Significant test : $\chi^2 = 75.9$
with 1 degree of freedom,
significant at << 1%

In so far as pupils choosing a science based career might be expected to be committed to their science subjects, including physics, the validity of the committed physicist scale is demonstrated by the much greater tendency of the high scorers to choose a science career.

(b) Validity of the enjoyment scale

The pupils were asked to rate their attitudes to physics and other subjects on a three point 'interest' scale.

TABLE 5.2.6. 'ENJOYMENT' VALIDITY

Enjoyment score	Interest rating for physics		
	1. Dull	2. Not sure	3. Interesting
High	19	14	158
Low	58	32	36

Significance test : χ^2 = 94.1 with 2 degrees of freedom, significant at << 1%

High enjoyment scores are seen to be strongly associated with high interest ratings.

(c) <u>Validity of the learning by experiment scale</u>

The pupils were asked to rate the statement

"We work together in groups to do investigations and experiments"

on the three point scale; good method (3), poor method (1) and don't know.

TABLE 5.2.7. 'LEARNING BY EXPERIMENT' VALIDITY

Learning by experiment score	Rating of experiment statement		
	1. Poor method	2. Don't know	3. Good method
High	20	29	364
Low	38	51	239

Significance test : χ^2 = 28.2 with 2 degrees of freedom, significant at << 1%

A significantly greater number of high learning by experiment scorers rate the experimental method a good one.

(d) Validity of the problem-solving scale

High scores on this scale are indicative of a concern with the solution to problems posed in the physics laboratory. Pupils with a high problem-solving rating, taking the scale at its face validity, have an intrinsic motivation to satisfy themselves that they understand the meaning of their learning. Of the four attitudinal variables, this might be supposed to be the one most directly susceptible to measurement by the G.C.E. O-level physics examination.

The grades of the 517 pupils who sat the G.C.E. examination were scored on a six-point scale, and the simple correlation between the grade scores and problem-solving ratings calculated. A significant value of 0.24 was obtained.

A further validity check, that corrects to some degree the non-uniformity of the examination grade scale as a criterion measure of 'problem-solving' was performed by comparing the relative proportions of high and low scorers appearing in the 'A' and 'Unclassified' categories of the G.C.E. examination.

TABLE 5.2.8. 'PROBLEM-SOLVING' VALIDITY

Problem-solving score	O-level physics grade	
	A	Unclassified
High	42	32
Low	11	41

Significance test : $\chi^2 = 14.45$ with 1 degree of freedom, significant at << 1%

5.2.5. A COMPOSITE ATTITUDE SCALE

The correlations of table 5.2.4. suggest that three of the scales, committed physicist, enjoyment and problem-solving are closely associated. Table 5.2.9. shows the intercorrelation of the scale scores, which gives a firm confirmation of this deduction.

TABLE 5.2.9. INTER-SCALE CORRELATIONS

	Committed physicist	Learning by experiment	Problem solving
Enjoyment	0.74	0.01	0.61
Committed physicist		0.07	0.69
Learning by experiment			0.20

A correlation of 0.07 is significant at the 5% level, N = 741

A composite scale constructed by the summation of these three highly correlated sub-scales should have a high internal consistency. The Cronbach Alpha coefficient gives a reliability of 0.92 for the 21 items.

The composite scale can be taken to measure a commitment to physics: high scorers not only like the subject and the problems it poses, but wish to become even more strongly associated with physics by committing themselves to it as a career (and a life-style?).

5.3. FIFTH FORM MOTIVATION AND STUDY HABITS

5.3.1. MODIFYING THE ROWNTREE SCALES FOR SCHOOL USE

In Chapter 2 (2.3), the background to the 'Rowntree' scales of motivation and study methods was explained. These scales include 14 study methods and 14 motivation items. All but one of these items were retained as being directly applicable to secondary students. In a few instances, minor rewording by changing a reference from 'lecture' to 'lesson' was necessary. Other more substantial changes were:

(i) "My habit of putting off work leaves me with far too much to do at the end of term." (Rowntree)

rewritten as:

"I try to put off any work that I have to do for as long as possible", and

(ii) "I find it difficult to pick out the relevant points in a lecture unless they are written on the board or in a hand-out." (Rowntree)

rewritten as:

"I find it easy to pick out the main points in a lesson without them being emphasised by the teacher."

The 27 items were then tested with a group of 30 A- and O- level students. A simple item analysis was performed to identify any negatively discriminating items, but at this time a greater weight was put on the subsequent discussion with the students on the suitability and clarity of the wording of the items.

Following this evaluation of the scales it was decided:

(iii) to rewrite

"I play any game to win, not just for the fun of it." (Rowntree)

as

"It is important to me that I do better than other students, if I can."

(iv) to rewrite

"There's no point in trying to do things in a hurry: I prefer to take my time." (Rowntree)

as

"I usually hurry all my homework: there seems little point in spending more time."

(v) to add another study methods item,

"I like working to a set plan when writing an essay rather than letting my ideas flow out freely" and

(vi) to add another motivation item,

"I am determined to do my best in all subjects, even in those that least interest me."

These changes resulted in a 29-item study orientation scale of which 15 were believed to measure motivation (Appendix 5.3.1). A pilot test of the scale was then conducted with 48 sixteen year-olds following O-level courses. These students were then retested after a further six weeks, and test/re-test correlations were calculated (table 5.3.1).

TABLE 5.3.1. PILOT TEST : SCALE RELIABILITIES

Sub-scale comprising original or modified items according to 'Rowntree' allocation	Test/re-test correlation (N = 48)
Study methods (S)	0.64
Motivation (M)	0.88
Study orientation (S + M)	0.82

Although the scales of study methods and motivation were no longer identical with the Rowntree ones: 11 motivation and 11 study methods statements were substantially the same. Thus, an overall reliability of 0.82 compares favourably with that of 0.86 reported by Cowell for the original Rowntree scales, and, in addition, a correlation of 0.52 between study methods and motivation in the pilot test compares well with Cowell's value of 0.56.

Having demonstrated the consistency of the modified scales, some measure of validity was obtained by comparing the motivation score with a teacher estimate of general motivation on a five point scale - this gave a correlation of 0.70 (N = 41).

5.3.2 USING THE MODIFIED SCALES

Whilst acting as a research instrument in the wider sense, the study scale could be analysed with a refinement not possible with smaller samples. For instance, reference was made earlier to an element of dissatisfaction with the validity of some of the 'Rowntree' items - a factor analysis of data from a large sample would allow items to be re-allocated, if necessary, as well as confirming the nature of the two dimensions of the scale.

Data was obtained from 37 classes in 16 schools: a total of 726 students of mean age 16.0 years. The questionnaires were completed during normal physics lessons under examination conditions.

5.3.3 FACTOR ANALYSING THE SCALES

A principal factoring method produced nine factors with eigenvalues greater than unity. A varimax rotation caused four of the nine factors to be become recognisable.

Of course, in an ideal world just the two factors of study methods and motivation would appear. However, as it was known that these factors, as far as they are measured by the scales, were moderately correlated, it was clear that an oblique rotation of the factor axes would be more appropriate than the varimax rotation, where the axes are kept orthogonal. The analysis then continued with a limit of two oblique factors imposed on the extraction process. This gave separate factors of study methods (S) and motivation, but the loading of some of the items and the earlier nine factor analysis suggested that the motivation factor was a composite one. A three factor oblique solution (Appendix 5.3.2A) showed that this was indeed the case with two motivation factors of;

i) academic motivation (MA), as defined by items such as 20. "It is important for me to do very well in my studies" and 29 "I am determined to do my best in all subjects, even in those that least interest me" and

ii) self-confident motivation (MB), as defined by items such as 14. "I get disheartened and give in easily if something is too difficult for me", and 18 "I'm a pretty average student: I'll never be particularly good, so there is no point in striving to be something I am not".

Item correlations on the three sub-scales are shown in Appendix 5.3.2B. Seven of the original or modified Rowntree items moved across from the study methods to the motivation dimension or vice versa. Four items showed such low loadings that they were omitted. The intercorrelation of the sub-scale scores are given in table 5.3.2. Attention is drawn again to the correlation between the scores on the two major dimensions of study methods S and motivation M. The value of 0.47 compares with 0. 41 for higher education students with the Rowntree scales (Entwistle et al, 1971b).

Table 5.3.2. SUB-SCALE INTERCORRELATIONS

	MA	MB	M = MA + MB	MS = S + M
S	0.37	0.42	0.47	0.82
MA		0.40	0.78	0.69
MB			0.89	0.79
M = MA + B				0.89

[A correlation of 0.07 is significant at the 5% level]

The intercorrelations of the three sub-scale scores are all of a similar magnitude. This suggests that, in statistical terms, any pair of the three scores can be taken if summation is desired. Namely, MA + S or MB + S rather than MA + MB. However, the scores represent meaningful concepts: they are not simply arithmetical quantities to be manipulated regardless of any underlying conceptual homogenity. Thus, the most valid summation is that of MA + MB to obtain a composite motivation measure M.

5.3.4. RELIABILITY AND VALIDITY

The internal consistencies of the three sub-scales and the two derived scales were calculated from the Kuder-Richardson formula 20, which is a severe measure giving a lowest possible index for a scale reliability. Table 5.3.3 shows these values.

Table 5.3.3. INTERNAL RELIABILITIES OF THE SUB-SCALES

Sub-scale	Number of items	Reliability by K.R.-20
S	10	0.66
MA	7	0.50
MB	8	0.60
M	15	0.68
MS	25	0.77

The low values for the motivation sub-scales mean that interpretation of educational outcomes in terms of these scales would be somewhat speculative and, at the moment, their use is in pointing in the direction of further research. Nevertheless, the composite motivation and study methods scales are likely to be more stable: a deduction that was confirmed by the results of a test / re-test programme with a two week interval. The data from two classes of 35 fifth-form pupils appears in table 5.3.4.

TABLE 5.3.4. TEST / RE-TEST RELIABILITIES

Scale	Test / re-test correlation (n = 35)
Study methods (S)	0.84
Motivation (M)	0.76
Study orientation (S + M)	0.87

It is likely that the much improved reliability of the study methods scale (compare with table 5.3.1) is due to the reduction in the interval between tests. The nature of the population at this level is such that a six week period, during which preparation for external examinations becomes a stronger influence, is always more likely to have an effect upon study habits, even if not upon motivation.

Entwistle et al. (1971b) were able to demonstrate the validity of the original Rowntree scales by correlating scores with the 'Brown-Holtzman' scales and other independent measures. Although the present study orientation scale has been derived from an already validated test, it was felt that before its use in a new educational environment further validation checks should be performed at the secondary level.

Table 5.3.5. VALIDATION OF 'M' SUB-SCALE

Class	N	Correlation r between teacher rating and M	Significance level of r
A	24	0.49	<5%
B	20	0.83	<1%
C	21	0.29	not sig.
A+B+C	65	0.55	<1%

The validity of the motivation scale was checked by asking teachers to rate students on a five point motivation scale (Appendix 5.3.3). The highest correlation was obtained with the estimates supplied by a teacher with a three year acquaintance with his students. The lowest correlation was obtained with the same teacher drawing upon just an eight months experience with class C (table 5.3.5).The teacher for class A had about two years of this relevant acquaintance. The mean correlation for all three classes was 0.55, which compares favourably with previously reported validation studies of this type (for example, Hartley et al, 1971).

An important research point arises here: the quality of the teacher criterion of motivation should not be assumed. Table 5.3.5 neatly shows how an improvement in the correlation follows from an increase in teacher-student contact time. Of course, the motivation scale might not measure 'absolute' motivation, but it is the invariant factor whilst both the teacher and teach-student contact time variables change. Hence, it is reasonable to take the correlation for class B as a better estimate of the validity co-efficient than the 'mean'of 0.55.

All completing the study methods scale subsequently took the physics examination at either G.C.E. O-level or at C.S.E. level. This allowed the validity of the scale to be checked. By making use of a five point scale of agreement with the statement:

> "My study habits in physics, compared with those in other subjects are much more organised..."

the scores on the general study methods scale could be weighted (Appendix 5.3.4A) and the correlation with attainment investigated.

TABLE 5.3.6. VALIDATION OF 'S' SUB-SCALE

Sample	Sample size	Correlation of attainment in physics with the weighted study methods scale	Significance level
All students	675	0.26	<1%
Boys	495	0.27	<1%
Girls	180	0.25	<1%

The significant correlation with examination grades can be taken as a measure of the validity of the scale.

5.3.5. PHYSICS STUDY HABITS AND MOTIVATION

Scores for physics study habits and physics motivation were obtained by using five-point rating scales to qualify or weight the responses to the general study orientation items. The physics study habits rating scale has been referred to in the last Section. The stem of the physics motivation rating scale is:

"Comparing my determination to do well in physics with that in other subjects, in physics...."

(Appendix 5.3.4B)

Physics study habits and motivation scores were calculated for several classes used in the test/re-test checks. Reliability coefficients for the classes with the two week interval between test and re-test were greater than those with a six week gap (Section 5.3.3) and are shown in table 5.3.7 for 73 pupils from three classes.

TABLE 5.3.7. TEST/RE-TEST RELIABILITIES

Scale	Test/re-test correlation (N = 73)
Physics study habits	0.82
Physics motivation	0.81

The correlation between physics study habits and attainment (table 5.3.6) has already been taken as a measure of the validity of the study habits scale. Validity of the physics motivation scale is perhaps more satisfactorily

TABLE 5.3.8. VALIDATION OF PHYSICS MOTIVATION SCORES

Class	N	r	Significance level of r
A	24	0.68	<1%
B	20	0.84	<1%
C	21	0.41	not sig.
A + B + C	65	0.64	<1%

established by correlating these scores with teacher estimates of physics motivation on a similar five-point motivation scale to that described in Section 5.3.4, but this time asking for motivation in physics to be rated. The same classes and teachers were used as for the general motivation validity check and with similar results (table 5.3.8.). The least experienced teacher of Class C is again less able to estimate his pupils' motivation. The correlations between teacher estimates and pupils scores (r) tend to be slightly higher than in table 5.3.5. indicating that it might be easier for a teacher to rate motivation in a particular subject than it is in general terms.

5.4. FIFTH-FORM PHYSICS CLASSROOM ENVIRONMENT

5.4.1. MEASURING PUPILS' PERCEPTIONS OF THE CLASSROOM ENVIRONMENT

The choice of measuring instrument from those available (Section 2.6) was effectively determined by the naturally limited access to classrooms in the year of the O-level examination and the need to measure, within the time available, a whole range of variables. Consequently, the lengthy scales of Gardner (1976) and Anderson and Walberg (1976) were inappropriate when judged by the completion time criterion. Pell's check-list thus remained the only readily available measure, and, although its earlier history included only rudimentary statistical analysis (Pell, 1975), the apparently sound psychological consistency of the findings previously obtained suggested that it was capable of discriminating between likely classroom 'types'.

Four items referring to examination preparation were deleted from the check-list before it was administered to 741 pupils in 37 classes. The original check-list had been used in the third term during the examination preparation period. As the design of the present research required the administration of the check-list during the first term in the fifth-form, it was felt that pupils would be unable to give valid responses to items which, at that time, would be partly hypothetical. The 19-item check-list is shown in table 5.4.1. Every item was to be rated on each of two scales A and B. Scale A was the pupil preference scale with the intrinsic worth of the method expressed by the item being scored 3 for 'good', 1 for 'poor' and 2 for'don't know'. Scale B measured the pupil's perception of reality with a 'degree of use' rating, scoring 3 for 'often', 1 for 'seldom' and 2 for 'don't know'. Appendix 5.4.1. shows the lay-out of the items on the questionnaire.

TABLE 5.4.1. CHECK-LIST RESPONSES

	Statement describing teaching method	Mean score (N=741)	
		Scale A Intrinsic worth	Scale B Degree of use
1.	The teacher talks or writes and shows some experiments	2.51	2.67
2.	The teacher asks us questions as we do some theory or practical work, gives us notes, and generally guides us in the right direction	2.56	2.29
3.	The teacher discusses each new topic with us, then we investigate this by ourselves and draw our own conclusions without further assistance	1.74	1.27
4.	The teacher's methods are varied such as allowing us to experiment, showing films and filmstrips, discussing and explaining with a single demonstration experiment	2.51	1.56
5.	The lessons are planned to make experimental and theory work run smoothly	2.55	2.14
6.	Homework set is linked with the lesson	2.71	2.68*
7.	The teaching seems to be most suitable for the most able pupils	1.74	2.24
8.	The teacher uses words rather than mathematical formulae whenever possible	2.29	1.92
9.	We work through a text-book	1.83	1.77*
10.	Each topic we study is linked to another one we have previously understood	2.63	2.01
11.	The teacher tries to get us to understand ideas by explaining in simple terms	2.76	2.34
12.	Duplicated notes are issued at the end of each lesson	2.02	1.14
13.	We make our own notes from text-books or work sheets	1.86	1.86*
14.	Groups of pupils make notes on different topics and these notes are circulated around the class	1.43	1.13

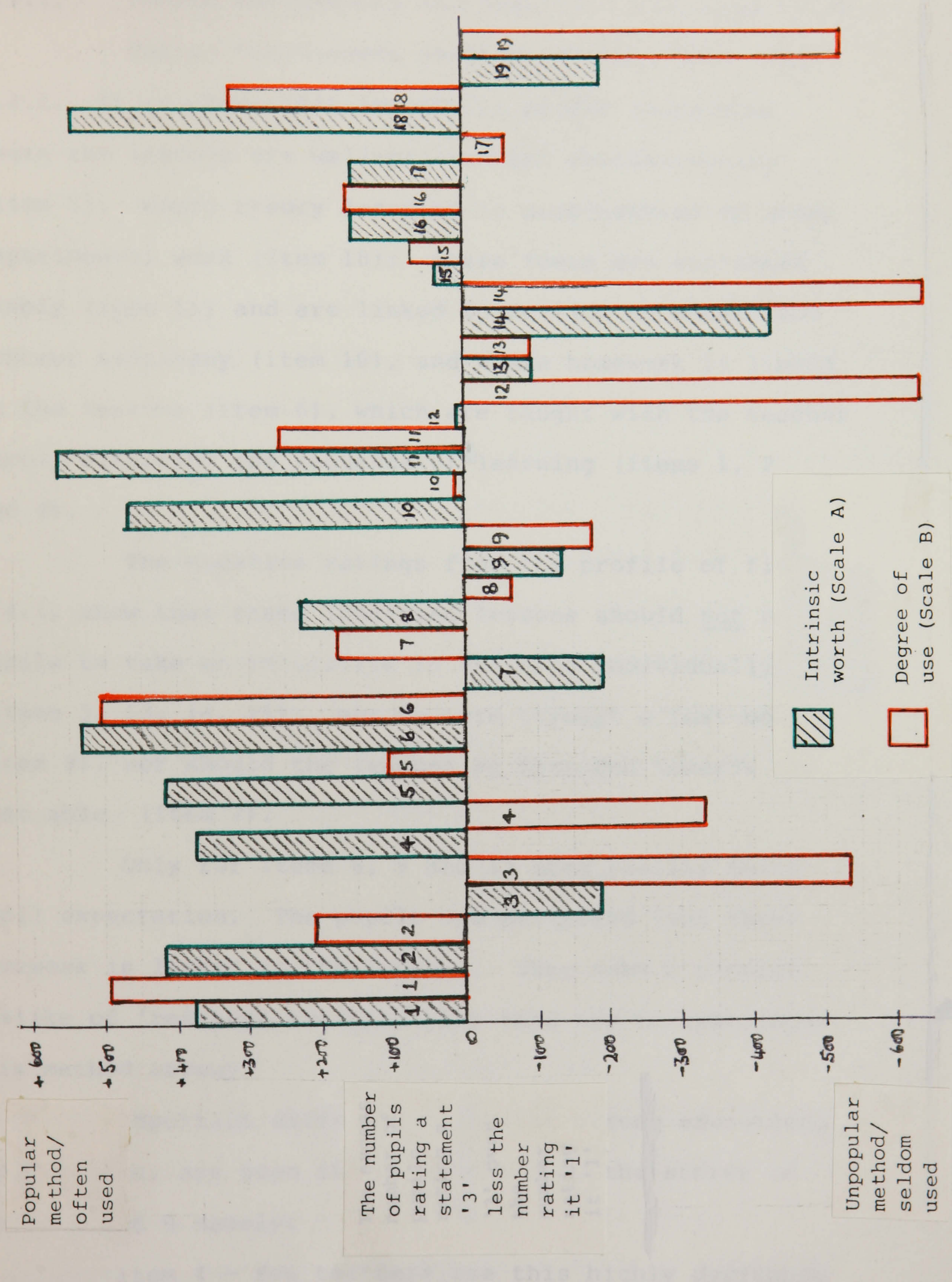
15.	Notes are made from dictation by the teacher	2.05	2.09*
16.	Notes are made by copying from the board or overhead projector	2.20	2.22*
17.	Notes are made by a number of different methods	2.20	1.92
18.	We work together in groups to do investigations and experiments	2.74	2.44
19.	We work individually through worksheets	1.73	1.29

*Difference NOT significant (Wilcoxon)

The differences in mean scores for scales A and B identify the statements where there is least matching between the pupil's ideal and reality. However, the distributions of the scores on the short rating scales may be different, even if the means are similar. The most appropriate statistic to test for significant differences between the A and B scales appears to be the Wilcoxon test (Siegel, 1956). When this test is applied to the scale distributions, all pairs of item scores are significantly different at the 1% level with the exception of those indicated in the table by an asterisk. (The parametric 't'-test statistic gives the same results). Appendix 5.4.2. shows the patterns of the responses to the 19 items.

Figure 5.4.1. shows another presentation of the differences in responses to the statements. For both the 'intrinsic worth' and 'usage' versions of each statement, the excess number of pupils scoring '3' over those scoring '1' was calculated. Thus, a value of +200 indicates that 200 more pupils rate the statement '3' than rate it '1', while a value of -150 shows that a majority of 150 rate

FIGURE 5.4.1. THE PROFILE OF RESPONSES



the statement '1' rather than '3'.

5.4.2. PUPILS PREFERENCES AND REALITY - THE GLOBAL VIEW

Taking the highest positive ratings from figure 5.4.1., it is clear that the pupils prefer classrooms where the lessons are well-planned and smooth-running (item 5); where theory learning is supplemented by group experimental work (item 18); where ideas are explained simply (item 11) and are linked to develop an understood concept hierarchy (item 10), and where homework is linked to the lessons (item 6), which are taught with the teacher firmly directing the sequence of learning (items 1, 2 and 4).

The negative ratings from the profile of figure 5.4.1. show that these idealised lessons should not require pupils to take an initiative in learning individually (items 3, 13, 14, 19); nor to work through a text-book (item 9), nor should the lessons be directed towards the most able (item 7).

Only for items 6, 9 and 13 does reality match pupil expectation. The pupils are satisfied that their homework is linked to the lessons. They show a general dislike of 'textbook teaching' but tend not to experience this method anyway.

Important differences, having strong educational implications, are seen in the mismatch of the scores on scales A and B namely:

item 4 - few teachers use this highly desirable style;

item 5 - a significant number of lessons are not well planned and smooth running;

item 7 - too often the teaching seems to be directed towards the most able;

item 8 - there is a tendency for the physics to become too mathematical;

item 10 - there is a likelihood that pupils will not be building up a system of understood concepts, and

item 12 - the use of duplicated notes is a neglected area in the recording of lesson content.

The conclusions at this stage are global, referring to a composite pattern made up from 37 separate classroom contributions. The fact that the global conclusions are meaningful does not mean that the same profile of match and mis-match is to be found in all the contributing classrooms (Section 2.6). Indeed, it is possible that no one classroom will display exactly that structure of characteristics which has just been identified.

5.4.3. THE PROFILE BREAKDOWN FOR INDIVIDUAL CLASSES

For each of the classes, mean scores for each pupil were calculated on scales A and B. The statements were then arranged in rank order on each scale A and B, and a rank-order correlation coefficient calculated as a measure of the degree to which the classroom environment provided matches the pupils' expectations. When this procedure is applied to the sample as a whole (the data of table 5.4.1.), a correlation of 0.73 is obtained.

Two examples of this procedure now follow (table 5.4.2). Classes X and Y show the best and worst degrees of match, respectively, in the survey.

TABLE 5.4.2. MATCH AND MIS-MATCH IN TWO CLASSROOMS

Statement	Class X N = 17 Mean Score		Class Y N = 23 Mean Score	
	Scale A Intrinsic worth	Scale B Degree of use	Scale A Intrinsic worth	Scale B Degree of use
1	3.00 (2.5)	2.88 (5)	2.57 (5)	2.26 (7)*
2	3.00 (2.5)	3.00 (2.5)	2.74 (4)	1.44 (15)*
3	1.77 (13)	1.18 (14)	1.44 (17)	1.61 (13)
4	2.35 (4.5)	1.53 (13)	2.48 (8)	1.13 (18)*
5	2.71 (8)	2.65 (8)	2.39 (10)	1.87 (10)*
6	3.00 (2.5)	3.00 (2.5)	2.83 (2.5)	2.65 (3)*
7	1.47 (17)	1.59 (12)	1.30 (19)	3.00 (1.5)
8	2.53 (9)	2.71 (7)	2.48 (8)	1.83 (11)*
9	1.53 (16)	1.06 (16)	1.74 (16)	2.61 (4)*
10	2.82 (6)	2.24 (9)	2.83 (2.5)	1.35 (16)*
11	2.88 (5)	3.00 (2.5)	2.91 (1)	1.65 (12)*
12	1.71 (14.5)	1.00 (18)	2.35 (11)*	1.57 (14)*
13	1.71 (14.5)	1.00 (18)	1.87 (14)	3.00 (1.5)
14	1.12 (19)	1.06 (15)	1.39 (18)	1.00 (19)
15	2.41 (10)	1.88 (10)	2.22 (12)	1.91 (9)
16	2.77 (7)	2.77 (6)	1.78 (15)*	1.17 (17)*
17	2.35 (11.5)	1.82 (11)	2.48 (8)	2.52 (5)*
18	3.00 (2.5)	3.00 (2.5)	2.52 (6)*	2.30 (6)*
19	1.35 (18)	1.00 (18)	1.91 (13)	2.00 (8)*

The rank orders of the statements appear in brackets
*$p < 5\%$ (Wilcoxon Rank-Sum test) for either Scale A or Scale B means.

Class X, with much the better match, shows a correlation between scales A and B of 0.92: the value for class Y is -0.07 (a correlation of 0.34 is significantly different from zero at the 5% level).

The rank order correlation procedure can provide further useful information about the classes. Returning to table 5.4.1. where the mean scores for all pupils appear, the rankings on Scale A can be compared with the separate class rankings on this scale. The coefficients for the two classes X and Y in this case are 0.91 and 0.92, respectively, showing that the classes differ little from the population norm in their preferences.

The teacher of class Y is clearly much less able to match the teaching method to the pupils' perceived need, while the class X teacher has a much more sympathetic style. The areas of discordance in the style of the class Y teacher, are identified from scales A and B in table 5.4.2 and are to be found in:

(a) the inability to establish an understood concept hierarchy (item 10), presumably because of a poor explanation of the concepts (item 11), which makes the teaching appear to be suited to the most able only (item 7);

(b) the medium of instruction - working through a textbook does not find favour with these pupils (items 9 and 13), and

(c) the overall presentation of lesson material, which does not involve the teacher in a benevolent questioning, illuminating and discursive role (items 2 and 4), but tends to be of a purely didactic style (item 1).

It can be hypothesised that two such classes as X and Y, subject to two disparate teaching styles, will demonstrate this difference in the two important outcomes of attainment in physics (O-level performance) and attitudes towards the subject (measured on the enjoyment scale of Section 5.2). Table 5.4.3 shows that class X does indeed display the more desirable outcomes.

TABLE 5.4.3. ATTITUDES AND ATTAINMENT DIFFERENCES

Outcome	Class mean scores (Standard deviation) X (N=16)	Y (N=14)
O-level physics score (A=6, B=5, etc.)	4.69 (1.02)	3.50 (1.74)*
Physics enjoyment score	29.88 (4.75)	24.00 (3.60)**

*p < 5% : ** p < 1% (t-test)

Any relationship between attitude, attainment and teaching style must remain hypothetical, of course. Table 5.4.3 expresses an association only. Classes X and Y were in no way matched for attitude and attainment before being 'exposed' to their respective teachers. It is conceivable that the characteristics of the class Y teacher could bring about positive results under some circumstances. However, such is the nature of the three areas of discordance in this particular style that intuition suggests these circumstances would have to be rather unusual. For instance, teaching physics to a class of rote-learning overseas students is a possibility (Sardar, 1977).

The web of relationships between attainment and methodology is explored in Section 7.4. To pursue this inquiry, it is necessary to reduce the scales A and B into a more manageable form, if at all possible, by grouping the responses to the items into conceptually homogeneous units by means of factor analysis (Section 5.4.5).

5.4.4. THE VALIDITY OF THE 'DEGREE OF USE' SCALE B

The check on the validity of the pupils' responses to scale B, visits were made to some classrooms to observe the nature of the pupil-teacher interactions and the styles of the teachers. It was hoped, initially, to obtain some measure of the type of cognitive and affective exchanges in the classrooms to complement the pupil questionnaire data. Consequently, a modified form of the Science Teaching Observation Schedule (Eggleston et al., 1976) was developed and tried out (Appendix 5.4.3A/B). In the event, the limitation on the time available for school visits meant that only three classes could be observed, so the original purpose of the Schedule was modified, and the data collected used to prepare a criterion rating of the statements of scale B against which class mean scores on this scale could be compared.

Table 5.4.4 shows the 19-item correlations for the three classes.

TABLE 5.4.4. SCALE B VALIDITY

Class	Correlation between observer rating and pupils' mean rating
A	0.71
B	0.68
C	0.78

A correlation of 0.34 is significantly different from zero at the 5% level.

The mean correlation of 0.73 is thus a measure of the validity of the pupils' perceptions of the activities within their classrooms.

Some qualification of this validity coefficient is necessary. The classes observed were not the same classes who had contributed to the original scale B pool of data. Rather, classes A, B and C were being taught a similar course by the contributing physics teachers in their 'normal style' approximately 12 months later. It is reasonable to suppose that, in these circumstances, the teaching methodology being observed will have changed little (Good et al., 1975; Eggleston and Dreyfus, 1977). A second, perhaps more important point, is that a single visit to a class is unlikely to sample the full range of a teacher's 'normal style', so the observer derived criterion scale will inevitably contain some inherent error.

5.4.5. FACTOR ANALYSING THE SCALES

To identify conceptual patterns in pupils' preferences for learning, scale A responses were subject to a principal components factor analysis. Seven first order factors were found to have eigenvalues greater than unity, accounting for 50% of the total variance. The conceptual structure of these initial factors was weak. A second order factorisation suggested that the most meaningful clusters of items would occur if a three-factor primary factorisation was performed with both orthogonal and oblique rotations of the factor axes.

Appendix 5.4.4 shows the final correlation matrix.

Factor scores were then computed by adding the item scores for those items which showed the greatest loading on a factor. Where under this procedure an item could be equally well allocated, in statistical terms, to more than one factor scale, the item was inspected for conceptual consistency before its allocation to one of the three scales. After this inspection, item 1 still remained on two scales, however, as did items 3, 4 and 14, although in the latter instances the scoring of the item was reversed on the second scale to reflect the different directions of the correlations.

The first scale appears to measure a preference for a strongly teacher controlled environment, where the pupils occupy the role of 'recorders'. Table 5.4.5. shows the relative strengths of the items on the scale by means of the correlation coefficients.

TABLE 5.4.5. THE 'TEACHER-CENTRED/NOTEMAKING' STYLE

ITEM		Correlation of item score with scale score
1.	The teacher talks or writes and shows some experiments	0.50
3.	The teacher discusses each new topic with us, then we investigate this by ourselves and draw our own conclusions without further assistance (Scoring reversed)	-0.50
4.	The teacher's methods are varied such as allowing us to experiment, showing films and filmstrips, discussing and explaining with a single demonstration experiment (Scoring reversed)	-0.36
14.	Groups of pupils make notes on different topics and these notes are circulated around the class (Scoring reversed)	-0.49
15.	Notes are made from dictation by the teacher	0.54
16.	Notes are made by copying from the board or overhead projector	0.52

The teacher is the source of information about physics. The pupils are seen as taking little part in the learning processes. Pupil activity is not popular, as the negative ratings of items 3, 4 and 14 show. A single method of presentation is desired: the formal lecture approach seems an appropriate description of the preferred style. Once the substance of the lesson has been presented, the pupils become active - recording the lesson content at the direction of the teacher by dictation or by copying.

There is no doubt that this first preference style has validity. In Section 2.8 , reference is made to Wankowski's "one-way" communication method in physics classes and to the widespread use of traditional lecture styles of science teaching (Shulman and Tamir, 1973). The evidence is that such teacher-centred styles are commonly practised. From the current study it is clear that pupils recognise this particular teaching method and are capable of expressing a preference for it.

The second preference method (table 5.4.6) emphasises understanding in simple terms in well planned lessons. Homework linked to the lessons has a strong part to play. Notemaking should be by varied methods. Topics are expected to be linked together, building one upon another with verbal rather than mathematical explanations. Experiments are expected to be performed, by both pupils and the teacher, with the latter guiding the learning in a comprehensive and varied manner.

The preferred style being measured by this scale

TABLE 5.4.6. THE 'VARIED/TEACHING-FOR-UNDERSTANDING' STYLE

Item	Correlation of item score with scale score
1. The teacher talks or writes and shows some experiments	0.45
2. The teacher asks us questions as we do some theory or practical work, gives us notes, and generally guides us in the right direction	0.46
4. The teacher's methods are varied such as allowing us to experiment, showing films and filmstrips, discussing and explaining with a single demonstration experiment	0.38
5. The lessons are planned to make experimental and theory work run smoothly	0.43
6. Homework set is linked with the lesson	0.48
8. The teacher uses words rather than mathematical formulae whenever possible	0.47
10. Each topic we study is linked to another one we have previously understood	0.43
11. The teacher tries to get us to understand ideas by explaining in simple terms	0.48
17. Notes are made by a number of different methods	0.45
18. We work together in groups to do investigations and experiments	0.30

is one which recognises explicitly the nature of science (the place of the experiment and the linking of concepts), and which requires a specific approach that cannot be identified with other subject areas. For example, the teacher-centred/notemaking preference might be equally applicable in a non-scientific subject. There appears to be psychological soundness in the varied/teaching-for-understanding preference, where learning by experiment and the use of visual aids is linked to a verbal, understood concept hierarchy. Earlier, in Sections 2.6 and 2.8 , these particular preference factors emphasising variability, classroom organisation and concept learning through experimental work, were encountered as part of a possible optimum style of science teaching in what was termed an 'intermediate', guided discovery approach.

The third preference dimension is that of pupil centred/textbook teaching (table 5.4.7), where the emphasis is on individual pupil activities (items 3, 9, 13 and 19).

TABLE 5.4.7. THE 'PUPIL-CENTRED/TEXTBOOK' STYLE

	Item	Correlation of item score with scale score
3.	The teacher discusses each new topic with us, then we investigate this by ourselves and draw our own conclusions without further assistance	0.46
7.	The teaching seems to be most suitable for the most able pupils	0.40
9.	We work through a text-book	0.47
12.	Duplicated notes are issued at the end of each lesson	0.45
13.	We make our own notes from textbooks or work-sheets	0.48
14.	Groups of pupils make notes on different topics and these notes are circulated around the class	0.39
19.	We work individually through work-sheets	0.51

There is a preference for learning through the use of text books and work-sheets. Duplicated notes are expected to be issued, although sometimes notemaking is supplemented by co-operative pupil effort. The teacher is expected to initiate enquiry (item 3) directed towards the most able pupils, but otherwise has an essentially passive role.

There is an element of discovery learning about this preference. However, this is not discovery learning in the usual 'Nuffield' terms. Rather, it is learning about a subject, not exclusively a science, from some reference or text-book source. The 'bookish' scholars attracted to this method expect the classroom to be oriented towards able pupils.

The three preference scales have recognisable face validity and compare to some degree with the observed teaching styles in physics classrooms identified by Houston and Eggleston et al. (1976). The teacher-centred/notemaking preference closely resembles the fact-acquiring expository style observed in the earlier studies. The varied/teaching-for-understanding preference corresponds to the teacher guided, problem-solving style. Only the third preference dimension appears unique, although 'text-book teaching' is far from uncommon (Smith et al., 1968; Comber and Keeves, 1973; Sardar,1977)and an amalgam of this approach with pupil initiatives could under certain circumstances prove attractive to some pupils. Indeed, one recent A-level project in physics (Gonzalez and Gilbert, 1980) has attempted to develop an independent learning approach based upon a similar philosophy to help to overcome deficiencies in teacher supply.

5.4.6. PREFERENCE SCALE RELIABILITY

The generally low magnitudes of the correlations reported in Appendix 5.4.4 between items and factor scores suggests that any internal reliability measure derived from the variance distribution, as is the Cronbach Alpha coefficient for instance, would be on the low side. This proves to be the case. Only the varied/teaching-for-understanding scale achieved a reliability coefficient of more than 0.50.

It is possible to bring about some marginal improvements in reliability by deleting some of the low loading items from each of the scales, but this procedure is of doubtful worth because, at the same time, the psychological concepts expressed by the scales are themselves weakened. The scales were therefore left unaltered and administered to a sample of 59 sixteen year-olds studying physics in four classes. A re-test was performed after three weeks, and correlations of scale scores obtained as reliability coefficients (table 5.4.8.)

TABLE 5.4.8. PREFERENCE SCALE RELIABILITIES

Scale	Test/re-test correlation
Teacher-centred/notemaking	0.50
Varied/teaching-for-understanding	0.75
Pupil-centred/textbook	0.42

A correlation of 0.26 is significantly different from zero at the 5% level.

The reliability of the varied/teaching-for-understanding scale is just acceptable (Gardner, 1975b), but the other two scales, despite their apparent conceptual homogenities, lack the consistency for sound analytical work .

5.5. FIFTH-FORM SUBJECT ATTITUDES

5.5.1. SELECTING THE ATTITUDE SCALE

Referring to Section 2.2 , comparative data on subject attitudes can be most readily obtained by the repertory grid method of Duckworth and Entwistle. The research hypotheses (Section 3.2) demand the concise measurement of subject interest and difficulty. The extended scales used by Duckworth and Entwistle measure additional dimensions but Pell had subsequently used an abbreviated form of the scales to measure successfully just those attitudes demanded by the present research. Consequently, six bi-polar construct scales, which might reasonably be associated with subject interest and difficulty, were selected from the two earlier versions. The attitude grid appears in Appendix 5.5.1.

Nine major O-level subjects were chosen for pupil rating. The choice of this particular set of subjects was governed by its relevance to the pattern of A-level subjects at large (Pell, 1975,). Responses were scored as follows:

'3' for construct B,

'1' for the opposite construct A and

'2' for uncertainty.

5.5.2. USING THE ATTITUDE SCALE - ANALYSING THE DATA

Data was obtained from 37 classes in 16 schools. The attitude grid was administered under normal test conditions as part of the third fifth-form questionnaire, approximately three months after the first questionnaire unit. Pupil absence meant that the sample size was reduced to 655 for this attitude test.

The grid generates essentially ordinal data on a three point scale. Table 5.5.1. summarises the results in terms of means and standard deviations. (Strictly speaking, the median should be used as the measure of central tendency with an ordinal scale but would convey little information in this particular instance).

It is seen that not all pupils take all subjects. This causes any analysis using a matched-pairs technique, which compares any two subjects, to be hazardous. This is because the pupils used in a history-physics comparison, for instance, might hold different attitudes to physics than would the pupils in a French-physics comparison. Yet, the indices for history-physics and French-physics would be used to rank the three subjects.

The solution appears to be to use the Kolmogorov-Smirnov (KS) goodness-of-fit test (Siegel, 1956). The pupils' responses to a certain subject on a construct scale are judged quite independently. If these responses have no significant meaning, the three scoring categories will draw responses equally. Should the response distribution deviate from a random, uniform one, it is possible to calculate a z-score measuring the strength of this deviation (UMRCC, 1979). It is then possible to rank the subjects on each construct, in turn, using the z-score values.

TABLE 5.5.1. MEAN ATTITUDE SCORES

A (Score 1)		French	Physics	Geography	Biology	English Lit.	Chemistry	Maths	History	English Language	B (score 3)
Dull		1.93	2.37	2.40	2.77	2.10	2.49	2.51	2.38	2.26	Interesting
Contains Sufficient material		1.69	1.90	1.87	1.63	1.77	1.92	1.48	1.89	1.28	Contains too much material
Easy		2.22	2.49	1.76	1.75	1.96	2.32	1.95	1.76	1.55	Difficult
Exciting		2.33	1.95	1.94	1.57	2.21	1.78	1.88	1.89	2.03	Boring
Out of date		2.43	2.57	2.53	2.77	1.86	2.64	2.68	2.07	2.43	Modern
High prestige		1.89	1.48	1.96	1.57	1.88	1.55	1.41	1.98	1.65	Low prestige
Sample size	Boys	276	485	338	200	341	352	483	202	448	
	Girls	150	170	93	125	147	123	171	68	171	

Tables 7.5.1 to 7.5.6 (pages 256-258) show rank-orders of subjects, according to sex, for each of the six bi-polar construct pairs. The significance of these subject rank-orders is considered in Section 7.5.

5.5.3. FACTOR ANALYSING THE RESPONSES

The pupils physics scores on the six construct scales were factor analysed. Two factors with eigenvalues greater than unity were identified which, after an oblique rotation of the factor axes, were found to correlate significantly at -0.43. The factor pattern matrix of correlation coefficients appears in table 5.5.2.

TABLE 5.5.2. FACTOR PATTERN MATRIX FOR THE PHYSICS CONSTRUCT SCALES

Construct scale	FACTOR I 'satisfaction'	 II 'slog'
Interest	-0.608*	-0.268
Too much material	0.122	0.417*
Difficult	-0.055	0.599*
Boring	0.680*	0.194
Modern	-0.517*	0.094
Low prestige	0.410*	-0.008

An asterisk indicates a construct allocated to that factor

The two factors measured the interest-like and difficult-like dimensions as expected. Reversing the correlations for factor I reveals that interest in physics is accompanied by the excitement of following a modern, highly prestigious cause. A twelve-point 'satisfaction' score can thus be calculated from the appropriate summation of the four separate construct scores. Difficulty is apparently associated with overloaded course content, so factor II measures the amount of sheer effort or 'slog' needed to master physics. The 'slog' score is calculated from the direct summation of the 'too much material' and 'difficult' scores.

The correlation of 0.43 between 'satisfaction' and 'slog' suggests a degree of masochism on the part of physics pupils, achieving a feeling of well-being towards the subject despite the effort, persistency and difficulty they encounter.

5.5.4. THE RELIABILITY OF THE 'SATISFACTION' AND 'SLOG' SCALES

Scores for 'satisfaction' and 'slog' were computed for 44 pupils in two classes taking part in a test/re-test investigation of the grid with a three week time interval. As table 5.5.4. shows, acceptable test/re-test correlations were obtained to indicate the reliability of the summation procedure.

TABLE 5.5.3. THE RELIABILITY OF THE SUMMATED SCALES

Summated scale	Test/re-test correlation (N=44)
Physics satisfaction	0.83
Physics slog	0.72

A correlation of 0.30 is significant from zero at the 5% level

5.5.5. THE VALIDITY OF THE 'SATISFACTION' AND 'SLOG' SCALES

Scores on the satisfaction and slog scales were correlated with physics examination attainment (GCE O- level grade A=6, B=5 etc. and similarly for C.S.E.).

Table 5.5.4 presents the correlations by sex and examination.

TABLE 5.5.4. ATTAINMENT-ATTITUDE CORRELATIONS

Sample Sub-group	N	Correlation between variable and attainment: 'satisfaction'	'slog'
G.C.E. boys	375	0.25**	-0.37*
G.C.E. girls	128	0.20*	-0.24*
C.S.E. boys	95	0.15	-0.16
C.S.E. girls	25	0.30	-0.28

**p < 1%; *p < 5%

The pattern of correlations is similar across the four sub-groups. The small sizes of the C.S.E. groups mean that the correlations fail to reach significance, however.

For G.C.E pupils, the 'slog' factor is strongly associated with poor attainment. The pupils who find the subject difficult and overloaded in content might reasonably be expected to do less well in the G.C.E. examination, this association demonstrates validity of the 'slog' scale.

The validity of the 'satisfaction'scale must, for the present, rest in the face validity of the constructs which comprise it. The discussion of Section 2.3 points to a relatively weak association of attainment with attitudes. If the 'satisfaction' scale is a valid attitude measure, then the relationship shown for the G.C.E. pupils in 5.5.4 supports these earlier findings.

5.5.6. THE RELIABILITY OF THE KOLMOGOROV-SMIRNOV RATING METHOD

Administering the attitude grid to the two retest classes allowed test and re-test subject ranks to be drawn up for each of the six construct scales. Table 5.5.5. shows the rank order correlation coefficients which are measures of the reliability of the technique.

TABLE 5.5.5. CONSTRUCT SCALE RELIABILITY

Construct scale	Test/re-test correlation
Interesting	0.73
Too much material	0.70
Difficult	0.98
Boring	0.92
Modern	0.76
Low prestige	1.00

A correlation of 0.60 is significantly different from zero at the 5% level (Siegel, p.284). History is excluded from the rankings on the 'modern' construct becaase of possible ambiguity.

The lowest coefficient, on the 'too much material' scale arose, principally, because of an increase in the physics rating on the retest (Appendix 5.5.2.). This can be partly explained by the imminence of the G.C.E.'mock' examination at the end of the three-week retest interval. The pupils' perceptions of the amount of material to be covered in the physics course would be enhanced as they face the real problem of revising. However, the satisfactory values of the reliability coefficients do demonstrate the soundness of the Kolmogorov-Smirnov technique in this particular application.

5.6. CHOOSING A-LEVEL SUBJECTS

5.6.1. THE SUBJECT CHOICE GRID

To collect data on subject choice and enjoyment, a simple grid was incorporated into the design of the third fifth-form questionnaire (Appendix 5.6.1). The pupils were asked to indicate

a) the subjects they were studying in the fifth-form

b) the three subjects that they most enjoyed,

c) the subjects that they would prefer to study to A-level, chosen freely, and

d) a restatement of the A-level subject list under constrained choice conditions (a 'bound' choice, Section 2.7).

The form of the grid was very similar to the one used by Pell (1975). The results and statistical analysis of the choice patterns appear in Section 7.6.

5.7. REASONS FOR CHOOSING OR REJECTING PHYSICS AT A-LEVEL

5.7.1. THE CHECK-LIST OF REASONS

Check-lists of reasons for choosing or rejecting A-level physics were readily available from the author's earlier survey (Pell, 1975). The results of this earlier work, including pupil's comments to open-ended questions, suggested that further statements relating to the amount of experimental work in the O-level physics course and the place of mathematics should be added. Each of the two versions of the check-list then comprised 16 items.

5.7.2. USING THE CHECK-LIST

The check-list was incorporated into the design of the third questionnaire unit and was administered at the end of the second term to 657 pupils in 37 classes. It was known from the responses to other sections of this questionnaire that some 514 pupils would be continuing with their academic studies in the sixth-form, with 265 of these hoping to start A-level physics. This latter group, the 'choosers' were directed to version I of the check-list shown in table 5.7.1. The remaining potential sixth-formers, the 'rejectors', were directed to version II (table 5.7.2).

The two tables show the statements, code-numbers and the grid for the 'most important' rating just as they appeared on the questionnaire. The final column shows the percentage response rate. A more detailed treatment appears in Section 7.7 , but from a first analysis it appears that A-level physics is chosen mainly for career reasons and subject interest, and rejected because of difficulty and (anticipated) poor attainment.

TABLE 5.7.1. VERSION I OF THE CHECK-LIST: CHOOSING A-LEVEL PHYSICS

Each of the statements below could be a reason for choosing A-level physics. Please ring the code number of each statement that gives one of your reasons

		Code number	Percentage response (N=265)
1.	You have a high O-level physics grade	1	59
2.	You have a better grade in physics than in most other subjects	2	35
3.	University and/or career requirements	3	89
4.	It is not a main subject but it was decided by school/college timetable	4	3
5.	The O-level course was interesting	5	72
6.	You have heard that the A-level course is interesting	6	35
7.	The O-level course was easy	7	17
8.	Physics allows you to use your mathematical ability	8	51
9.	You are attracted by the amount of student experimental work in physics	9	29
10.	Not so much hard work is expected in A-level physics as in other subjects	10	5
11.	You have heard that it is easier to pass in A-level physics than in most other subjects	11	7
12.	You are attracted by the A-level teaching methods in physics	12	9
13.	You are attracted by the type of exams in A-level physics	13	5
14.	You have heard that it is more difficult to pass in A-level physics than in most other subjects, but you are confident that you can manage	14	27
15.	More hard work is expected than in some other subjects but you think you can manage	15	39
16.	To improve your understanding of science in the world today	16	62

Of the reasons you have indicated, which three do you think would be the most important ones in your case?

Please enter them in the table in order of importance:

FIRST	
SECOND	
THIRD	

TABLE 5.7.2. VERSION II OF THE CHECK-LIST: REJECTING A-LEVEL PHYSICS

Each of the statements below could be a reason for not choosing A-level physics. Please ring the code number of each statement that gives one of your reasons

		Code number	Percentage response (N=249)
1.	You have a low O-level physics grade	1	53
2.	Your physics grade is lower than the grades in most other subjects	2	53
3.	University and/or career requirements mean other subjects must be studied	3	35
4.	It would not have been a main subject and it could not be fitted into school/college timetable	4	13
5.	The O-level course was not interesting	5	48
6.	You have heard that the A-level course is not interesting	6	14
7.	The O-level course was difficult	7	73
8.	The O-level course was too mathematical	8	26
9.	There was not enough student experimental work in the O-level course	9	35
10.	You have heard that you must work much harder in A-level physics than in most other subjects	10	23
11.	You have heard that it is more difficult to pass A-level in physics than in most other subjects	11	35
12.	You are not attracted by the teaching methods of the A-level physics course	12	19
13.	You are not attracted by the type of A-level physics exam	13	27
14.	A-level physics will not allow your personal opinions to be expressed	14	21
15.	A-level physics is too narrow and specialist to be useful for you	15	27
16.	The A-level course seems to have too much mathematics in it	16	27

Of the reasons you have indicated, which three do you think would be the most important ones in your case?

Please enter them in the table in order of importance:

FIRST	
SECOND	
THIRD	

5.8. FIFTH-FORM EXAMINATION PREPARATION

5.8.1. PREPARATION OF THE PREFERENCE SCALE

Earlier research on the nature of the preparation required for optimum performance in the G.C.E. examination is almost entirely absent. One reason for this might well be the difficulty in gaining access to classes in the examination preparation period during the Spring and early Summer terms. Some evidence, nevertheless, has been collected by Pell (1975), who found from a pupil check-list that, in physics, the pupils prefer a planned O-level revision schedule with regular examination question practice. In reality, the actual teaching tended to provide for less question practice than desired. Whether this lack of 'match' had any significant impact on attainment and attitudes is not reported.

The classroom environment check-list described in Section 5.4.1 did originally include examination preparation items but these had to be removed because the design of the research required the check-list to be administered well before the end of the O-level course. The original four examination preparation items were reworded and expanded to include syllabus coverage. The complete scale comprised seven items, which appear in table 5.8.1. Responses were to be made on two parallel 3-point sub-scales, A and B, as described earlier for the main check-list. Scale A measured the pupils' preference for the method, while scale B asked whether the method was actually used or not. As the pupils were being asked whether a procedure was being followed at one specific time during the course, it was felt that the response categories on scale B should be 'true' or 'false' rather than 'often' or 'seldom' as were used on the 19-item check-list for classroom exchanges over the whole year.

5.8.2. INITIAL RESULTS

For valid completion of the examination preparation check-list, it had to be administered after the completion of the course. It was impractical to contact the pupils immediately after the examination period. The first available opportunity presented itself when those pupils still at school were in the lower sixth-form, some six weeks after the start of the A-level courses. The check-list was thus incorporated into the fourth questionnaire unit. Appendix 5.8.1. shows the format.

TABLE 5.8.1. EXAMINATION PREPARATION CHECK-LIST MEAN SCORES

Statement describing examination preparation method	Mean score (N=286) Scale A Intrinsic worth	Scale B Degree of use
1. We had regular practice in answering O-level examination questions	2.87	2.73**
2. A revision plan was followed by the class in the time before the examination	2.53	2.05**
3. Examination revision was done by using the student's own notes on the course	2.31	2.62**
4. The topics covered in the O-level course were thoroughly treated	2.43	2.08**
5. The O-level syllabus was completely covered	2.29	1.81**
6. All O-level topics covered in the course were revised for the examination	2.56	2.16**
7. The topics covered in the O-level course were restricted to those thought essential for an examination pass	1.79	1.84

Maximum and minimum scores are 3.00 and 1.00 respectively
**p < 1% (Wilcoxon test)

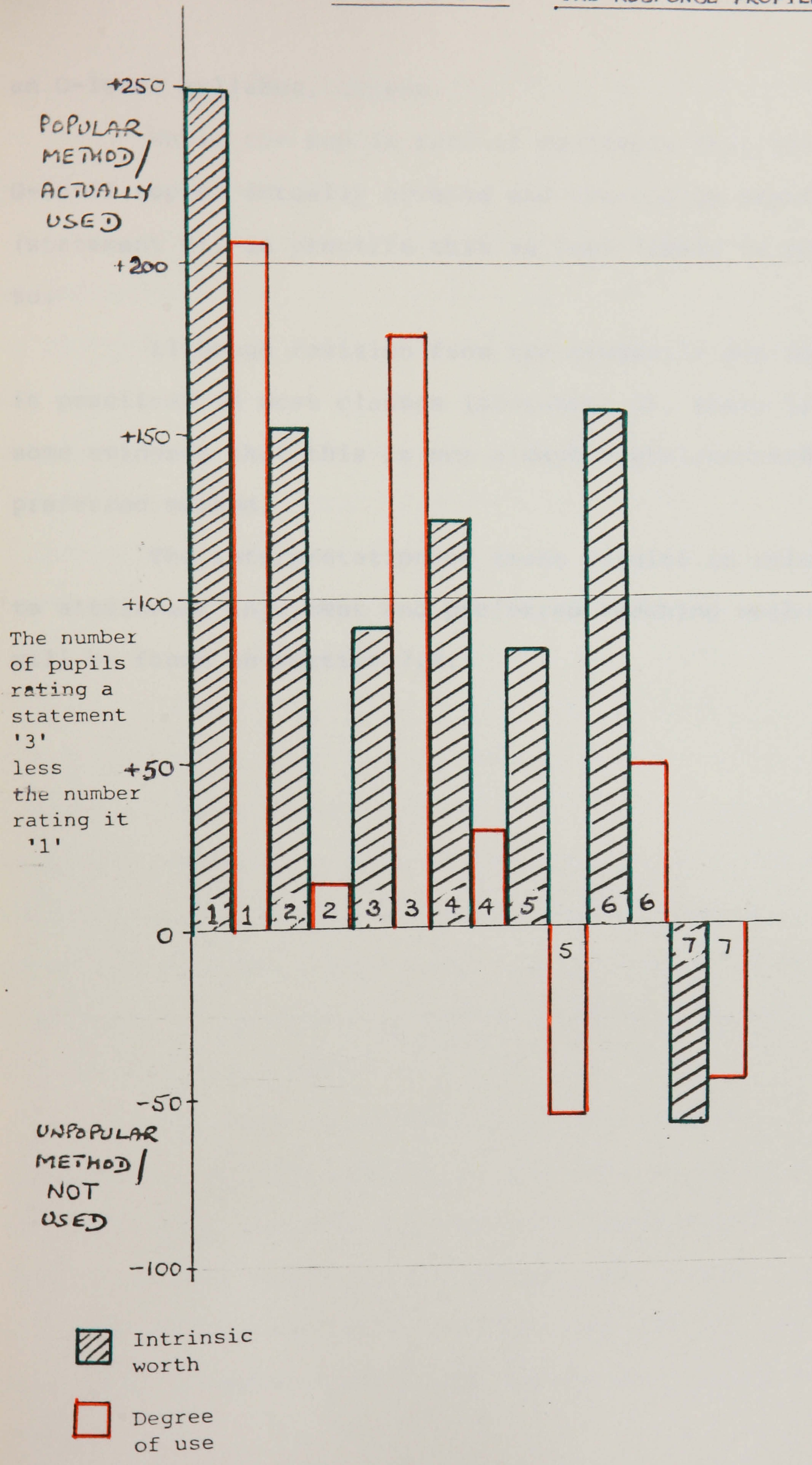
The differences between the mean scores for Scales A and B measure the amount of mis-match between the students' ideal and reality. As the rating scales spread over just three points, significant differences are more appropriately investigated by the Wilcoxon test (Siegel, 1956). The application of this test (Appendix 5.8.2) shows that the responses on the two scales are significantly different at the 1% level for all the statements except for the last.

Figure 5.8.1 shows these differences diagramically. A score of +50 indicates that 50 more students rate the statement positively (as a 'good method', that is) than rate it negatively: a score of -50 thus shows that there is a majority of 50 students rating the statement unfavourably.

From both table 5.8.1 and figure 5.8.1 , it can be concluded that an excessively examination oriented course is not popular (statement 7) but that <u>it is highly desirable that all O-level topics covered should be thoroughly revised according to some organised plan with regular question answering practice</u> (statements 1, 2 and 6). In reality, it appears that not all the topics are revised, neither is a revision plan always adopted.

The extensive nature of the typical O-level syllabus seems to have been appreciated by a number of students with only a minority, overall, rating it desirable that the O-level syllabus be completely covered. Responses on the 'degree of use' scale to this item show that it is very unlikely that a teacher would completely cover

FIGURE 5.8.1. THE RESPONSE PROFILE



an O-level syllabus, anyway.

While the pupils rate it desirable that all O-level topics actually covered are thoroughly treated (statement 4), in practice this is less likely to be so.

Although revision from the student's own notes is practised in most classes (statement 3), there is some evidence that this is not always a wholeheartedly preferred method.

The interpretation of these results in relation to attainment enjoyment and preferred teaching method will be found in section 7.8.

5.9. ATTITUDES TOWARDS PHYSICS IN THE SIXTH-FORM

5.9.1. CHOOSING THE ATTITUDE SCALE

Few attitude scales appear to have been used at sixth-form level in the U.K. An extensive survey of attitudes to sixth-form study generally has been conducted by the Schools Council (1970). From a research instrument point of view, this survey used simple semantic differential type rating scales to collect data on a number of bipolar constructs. A similar approach,with 15 seven-point scales, was used in the U.S. by Ahlgren and Walberg (Section 1.4) in their evaluation of the P.S.S.C. and H.P.P. courses. Pell (1975) has attempted to replicate this U.S. study by means of a 14-item semantic differential scale. Although no rigorous statistical treatment was used, Pell was able to discriminate effectively between traditional and 'Nuffield' A-level courses with the latter generally superior. There also appeared to be attitudinal differences between pupils following the courses of different G.C.E. examining boards.

The ready availability of Pell's scale, its conciseness, and the likelihood that data obtained with it could yield a stable and reliable factor solution, were all strong points in its favour, and it was decided to adopt it,with very minor modification, as the test instrument to monitor attitudes during the sixth-form course.

5.9.2. TESTING AND USING THE ATTITUDE SCALE

The attitude scale, which appears in Appendix 5.9.1 , was required to measure attitudes to physics in a pre-test/post-test design. It was thus incorporated in both the lower and upper-sixth-form questionnaire units. The lower sixth-form questionnaire was administered some six weeks after the beginning of the A-level physics course to give the students sufficient time to form valid, initial impressions. In the upper-sixth, the questionnaire was completed after the end of the second term, which was effectively at the end of the course and during the pre-examination revision period.

In all,151 boys and 39 girls in a total of 24 classes completed pre-test questionnaires. A significant drop-out occurred during the course with students changing to other subjects or leaving for employment.As a result, 108 boys and 35 girls in 23 classes remained to complete the post-test questionnaire.

Tables 5.9.1 and 5.9.2 give the mean scores on the pre-tests and post-tests, respectively. The scores are broken down by sex for later analysis in Section 9.2. Scores in these two tables appear within the range of +3 to -3, with the highest positive score being identified with the construct appearing in the table.

From table 5.9.1, the picture emerging at the start of the sixth-form course is that of an enjoyable subject of some considerable prestige.However, the course is difficult, mathematical, and requires much hard work.

The two significant sex differences indicate that boys find the subject less difficult than do the girls and enjoy it more.

TABLE 5.9.1. PRE-TEST SCALE SCORES

	Scale construct	Mean score (standard deviation)			
		Boys, N=151		Girls (N=39)	
1	Frustrating	-0.74	(1.39)	-0.44	(1.55)
2	Present day theories are considered, only	-1.13	(1.32)	-1.44	(1.02)
3	Requires little work	-2.23	(0.89)	-2.49	(0.68)
4	Dull	-1.50	(1.25)	-1.44	(1.29)
5	Enjoyable	1.05	(1.19)	0.56*	(1.25)
6	High prestige	1.21	(1.21)	1.46	(1.27)
7	Unpleasant	-0.99	(1.17)	-0.67	(1.13)
8	Social implications always considered	-0.40	(1.45)	-0.13	(1.44)
9	Contains sufficient material	0.27	(1.77)	-0.15	(1.37)
10	Makes you think deeply about your personal views	-0.46	(1.62)	-2.18	(0.85)
11	Non-mathematical	-2.21	(0.84)	-2.18	(0.85)
12	Exciting	0.68	(1.29)	0.26	(1.29)
13	Out of date	-0.98	(1.30)	-1.28	(1.00)
14	Easy	-0.99	(1.41)	-1.49*	(1.32)

* $p < 5\%$ (sex difference, t-test)

On the post-test (table 5.9.2), girls continue to find the subject more difficult than the boys. There is no longer any difference in subject enjoyment. Boys find the subject requiring less hard work and being less concerned with social implications than at the beginning of the course and now differ significantly from the girls on these constructs.

Both pre-test and post-test scale scores can be compared with a 'neutral' response (zero score) by calculating the standard error in the mean and assuming a normal distribution of sample means. The directions indicated by the signs of the mean scores are significant at the 5% level, at least, except for scale 1 (girls pre-test), scale 8 (girls both tests), scale 9 and scale 12 (girls both tests, boys post-test).

TABLE 5.9.2. POST-TEST SCALE SCORES

	Scale construct	Mean score (standard deviation)			
		Boys N = 108		Girls N = 35	
1	Frustrating	-0.34	(1.39)	-0.60	(1.27)
2	Present day theories are considered, only	-1.15	(1.27)	-1.36	(0.98)
3	Requires little work	-1.74	(1.28)	-2.20	(0.80)*
4	Dull	-0.82	(1.45)	-1.36	(1.29)
5	Enjoyable	0.72	(1.35)	0.91	(1.31)
6	High prestige	1.26	(1.30)	1.06	(1.26)
7	Unpleasant	-0.53	(1.29)	-0.60	(1.09)
8	Social implications always considered	-0.87	(1.48)	-0.26	(1.36)*
9	Contains sufficient material	0.00	(1.78)	0.57	(1.87)
10	Makes you think deeply about your personal views	-0.63	(1.82)	-0.54	(1.76)
11	Non-mathematical	1.57	(1.15)	1.94	(0.91)
12	Exciting	0.07	(1.33)	0.11	(1.21)
13	Out-of-date	-0.63	(1.29)	-1.04	(1.07)
14	Easy	-0.93	(1.43)	-1.80	(1.11)**

** $p < 1\%$; * $p < 5\%$ (sex difference, t-test)

5.9.3. FACTOR ANALYSING THE RESPONSES

In anticipation of a meaningful factor solution to the attitude scale responses, it was felt prudent to make arrangements for a test/re-test so that reliability estimates could be made. Consequently, some 84 students from schools not involved in the project were asked to complete the scale under controlled conditions and again after a two-week period.

The responses of all 190 pre-test students were pooled with those from the first test of the 84-strong test/re-test group. A principal components factor analysis of the responses to the 14 scale items was then performed. Both orthogonal and oblique solutions were inspected. Four factors were found to have eigenvalues greater than unity, accounting for 61% of the variance in the item scores. There was evidence that significant inter-correlation existed amongst the factors, so it was the oblique solution that was taken for further analysis. Table 5.9.3 shows the factor structure matrix (the correlation coefficients between the item and the factor scores).

TABLE 5.9.3. THE FACTOR STRUCTURE MATRIX OF CORRELATION COEFFICIENTS

		Factor			
	Scale construct	I	II	III	IV
1	Frustrating	-594*	-348	-385	231
2	Present day theories are considered only	-124	-027	-098	443
3	Requires little work	-003	854*	-026	-017
4	Dull	-820*	-089	-383	280
5	Enjoyable	848*	295	349	-349
6	High prestige	244	084	087	003
7	Unpleasant	-768*	-250	-324	361
8	Social implications always considered	195	059	488	-226
9	Contains sufficient material	395	439*	195	-245
10	Makes you think deeply about your personal views	217	048	525	004
11	Non-mathematical	054	522*	071	-009
12	Exciting	804*	306	470	-242
13	Out-of-date	-353	-013	-326	184
14	Easy	302	634*	164	-289

Decimal points are omitted

An asterisk indicates an item allocated to the respective composite attitude scale.

The nature of the five items contributing strongly to factor I identify this factor as a measurement of subject enjoyment or satisfaction. Taking into account the direction of the correlations, composite five-item 'enjoyment' scores ranging from 5 to 35 were calculated for each respondent.

Factor II expresses the relative easiness of the subject. It is interesting to note that the opposite pole of this factor, <u>subject difficulty, is strongly associated with a course having a highly mathematical emphasis.</u> Composite four-item 'easiness' scores, ranging from 4 to 28, were then calculated.

Together, factors I and II account for some 45% of the variance of the item scores. Factors III and IV, measuring humanistic and historical attributes, are of such weakness to preclude any serious attempts to sum item scores to derive overall composite scale totals. However, key items 2, 8 and 10 remain as individual attitude measures to join those other items which do not contribute to the composite 'enjoyment' and 'easiness' scales.

5.9.4. THE RELIABILITY OF THE TWO COMPOSITE SCALES

Two approaches were adopted. The first was to calculate internal consistency coefficients (Cronbach Alpha) for the 'enjoyment' and 'easiness' scales. The second was to use the data from 84-student retest group and to compare scores with a two-week test interval. Table 5.9.4 reports these findings.

The two composite scales are seen to demonstrate moderate reliability. The particularly high value of the Cronbach Alpha coefficient for the 'enjoyment' scale is possibly a measure of the similarity of the items rather than an indication of impressive stability of response.

TABLE 5.9.4. RELIABILITY COEFFICIENTS

Scale	Reliability coefficient	
	Cronbach Alpha (N = 274)	Test/re-test (N = 84)
Enjoyment	0.90	0.66
Easiness	0.67	0.72

For sample groups of N = 274 and N = 84 respectively, correlations significantly different from zero at the 1% level are 0.16 and 0.28.

5.9.5. CORRELATIONS BETWEEN THE COMPOSITE SCALES

Correlations between scores on the composite enjoyment and easiness scales are shown in table 5.9.5.

TABLE 5.9.5. MAJOR SCALE INTER-CORRELATIONS

	Correlations between the major scales	
	Pre-test	Post-test
Boys (N = 108)	0.35**	0.26**
Girls (N = 35)	0.36*	0.05

** $p < 1\%$; * $p < 5\%$

At the pre-test stage, both boys and girls show a significant association between the enjoyment of physics and its easiness. By the time the post-test is reached only the boys continue to demonstrate this association.

5.9.6. CORRELATIONS BETWEEN THE MAJOR AND MINOR SCALES

The 'minor' scales are those scale items which do not appear on either the composite enjoyment or easiness scales. Referring to table 5.9.3, these are items 2, 6, 8, 10 and 13.

Both pre-test and post-test data were used to correlate the minor scale scores with the two major ones. Tables 5.9.6 and 5.9.7 show the results for boys and girls, respectively.

TABLE 5.9.6. SCALE INTER-CORRELATIONS - BOYS (N = 108)

Scale item	Correlation between item score and			
	Enjoyment		Easiness	
	Pre-test	Post-test	Pre-test	Post-test
2 Present day theories are considered only	-0.08	0.00	0.05	0.06
6 High prestige	0.36**	0.36**	0.04	0.00
8 Social implications	0.19*	0.18	-0.12	-0.01
10 Makes you think deeply about your personal views	0.09	0.31**	-0.19*	0.07
13 Out of date	-0.33**	-0.38**	0.06	0.19*

** p < 1%; * p < 5%

Enjoyment of the physics course, for boys, is seen to be associated with a modern course with a high prestige rating. If the course appears philosophical in nature (item 10) or socially oriented then it is also likely to be enjoyed.

There is a weak association of easiness with an out-of-date course rating for the boys. This odd conclusion can be explained by the influence of the 'out-of-date' but 'easy' Oxford G.C.E. course (tables 9.2.7 and 9.2.8). At the beginning of the course, students rating it easy are less likely to see any personal meaning in the subject.

TABLE 5.9.7. SCALE INTER-CORRELATIONS - GIRLS (N = 35)

Scale item	Correlation between item score and			
	Enjoyment		Easiness	
	Pre-test	Post-test	Pre-test	Post-test
2 Present day theories are considered only	0.29	-0.21	0.20	0.14
6 High prestige	-0.14	0.06	-0.20	0.01
8 Social implications always considered	-0.01	0.03	0.02	0.30
10 Makes you think deeply about your personal views	0.43**	0.70**	0.42*	0.05
13 Out-of-date	0.01	-0.34*	0.10	0.21

** p < 1%; * p < 5%

Girls' enjoyment of physics is seen to be strongly associated with the perceived philosophical nature of the course. the evidence is that this association grows as the course progresses. The impact of an up-to-date course is also showing its effect on enjoyment by the time of the post-test.

The easiness of the subject shows a significant correlation with the girls 'philosophical' rating at the start of the course but, by the end, this association has disappeared..

5.10. MOTIVATION AND STUDY HABITS IN THE SIXTH-FORM

5.10.1. THE S.S.R.C. SCALES

Section 2.5 has described how the Rowntree scales of motivation and study habits were developed. It was also pointed out how a deeper understanding of the concept of motivation led to the search for an instrument which was capable of measuring with a greater degree of refinement. The design of the present research required appropriate measures of motivation, fear-of-failure and syllabus boundness which would not be possible from the original Rowntree scales or the modified forms of Section 5.2. Concurrently, an investigation of the effects of study styles associated with success in different academic disciplines in higher education was being conducted by Entwistle at the University of Lancaster. Access to these (S.S.R.C.) scales was kindly permitted (Entwistle, 1978a).

In addition to measuring the variables of particular interest to the present research study, the S.S.R.C. scales also allowed a study of the nature of a student's learning processes. Marton and Saljo (1976) have distinguished between 'surface-level' and 'deep-level' processing. In the former, a superficial, almost rote approach is adopted to the learning of the text itself. Deep-level processing demands an understanding of subject content: the meaning and implications of its inclusion in relation to the whole. Entwistle (1977) points out that over half first-year university students could well be 'surface processors'.

The present survey sample of second year A- level physics students were just one year removed from the poulation of higher education students being investigated in the S.S.R.C. project. The intended destination of the majority of sixth-formers was, indeed, higher education (Section 9.5). An inspection of the wording of the S.S.R.C. scales confirmed that they would be appropriate for use with upper sixth-formers. The scales were pre-tested, and subsequently discussed with a small sample of sixth-formers. Very minor rewording of some items was necessary to make them compatible with the school rather than university environment. Usually, this entailed the substitution of 'lessons' for 'lectures'.

The scales chosen for inclusion in the upper sixth-form questionnaire were those consistent with the research hypotheses and the review of Section 2.5 , namely

1. academic achievement motivation
2. organised study habits
3. fear-of-failure
4. syllabus-boundness
5. extrinsic motivation
6. intrinsic motivation

The need to prevent the questionnaire becoming excessively long unfortunately meant that the two 'processing' variables had to be excluded. The six scales comprised forty items which were randomly arranged and set out in the questionnaire as shown in Appendix 5.10.1.

5.10.2. SCALE RELIABILITIES

Data was obtained from 108 boys and 35 girls in 23 classes. Table 5.10.1 shows the reliability values supplied from the S.S.R.C. project. Table 5.10.2 gives Cronbach Alpha coefficients from the data of the present research. The 'marker' item for each scale is also given in each table. This item has the highest correlation with the scale score. The full scales and item statistics appear in Appendix 5.10.2.

The present survey and the S.S.R.C. project generate very similar item correlation statistics. Where there are differences, on the extrinsic motivation scale for instance, it is likely to be because of the nature of the institutions in which the two different student populations find themselves. The vocational reality of subject choice is likely to be more of an immediate influence for university students than for school sixth-formers taking A-levels, hence the higher item correlations for the former population.

Full results and the relationship of S.S.R.C. scale scores to other survey variables appear in Section 9.3.

TABLE 5.10.1. SCALE STATISTICS FROM THE S.S.R.C. STUDY

Scale	Number of items	Mean item-scale correlation	Defining item
Academic achievement motivation	6	0.57	I enjoy competition: I find it stimulating
Organised study habits	10	0.56	I'm rather slow at starting work in the evenings (Reverse)
Fear-of-failure	6	0.63	I get very anxious about work which is overdue
Syllabus boundness	6	0.55	I like to be told precisely what to do in essays or other assignments
Extrinsic motivation	6	0.64	My main reason for being here is that it will help me get a better job
Intrinsic motivation	6	0.66	I find that studying academic topics can often be really exciting and gripping

TABLE 5.10.2. SCALE STATISTICS FROM THE SIXTH-FORM SURVEY

Scale	Cronbach Alpha	Defining item
Academic achievement motivation	0.59	It's important to me to do really well in my course
Organised study habits	0.75	I find it difficult to organise my study time effectively (Reverse)
Fear-of-failure	0.56	I often find that my mind goes blank when I'm faced with a particularly difficult question
Syllabus boundness	0.56	I like to be told precisely what to do in essays or other assignments
Extrinsic motivation	0.49	My parents expect me to do well and I feel it is up to me not to let them down
Intrinsic motivation	0.68	I find academic topics so interesting I should like to continue with them after I finish this course

5.11 SIXTH-FORM PHYSICS CLASSROOM ENVIRONMENT

5.11.1 MEASURING STUDENTS' PERCEPTIONS OF THE CLASSROOM ENVIRONMENT

When choosing the classroom environment scale, the same criteria were applied as before when selecting the fifth-form measure (Section 5.4.1). A concise scale was desired, capable of completion within a limited time, yet a valid indicator of the perceived classroom environment and the preferences of the students.

A 39-item check-list had been previously developed by Pell (1975) and used with an identical student population. The preference profile obtained showed a clear face-validity with the students rating highly the need for discussion sessions and a recognisable, broad, hierarchical conceptual scheme running through the lessons as well as the more conventional teacher guided exposition (Gagné, 1970: Ausubel, 1968). This check-list was chosen rather than the more lengthy scales of Gardner (1976) and Anderson and Walberg (1976), but some further development work was necessary.

Most of the items on the original check-list were retained but a number of items were re-written in the light of the experience gained from the first study. A small pilot study was conducted to check on the suitability of the amended list and an accompanying interview schedule, which was to check on the validity on the check-list and other upper sixth-form questionnaire items.

The check-list, now comprising 40 items was administered to 143 students in 22 classes. The design was similar to that used for the fifth-form version. Every item was to be rated on each of two scales A and B. Scale A was the student preference scale requiring a rating of the intrinsic worth of the method expressed by the item (scored 3 for a 'good' method, 1 for a 'poor' method and 2 for 'don't know'). Scale B measured the students' perception of reality with a 'degree of use' rating (scored 3 for 'true', 1 for 'false' and 2 for 'sometimes'). Appendix 5.11.1 shows the lay-out of the items on the questionnaire.

Mean scores were calculated for each of the two responses to the statement of teaching method and are shown in table 5.11.1.

TABLE 5.11.1. CHECK LIST RESPONSES

	Statement describing teaching method	Mean score (N=143) Scale A Intrinsic worth	Scale B Degree of use
1	Teaching is by lectures with experimental demonstrations	2.53	1.97
2	Learning is by finding out by oneself after each new topic has been introduced by the teacher	2.06	1.57
3	The class works through a textbook	1.78	1.89*
4	The teacher guides you in your learning, acting as a source of information, asking questions and using experimental demonstrations to help	2.81	2.45
5	Part of the course is devoted to an individual student project	2.05	1.01
6	Individual homework and practical accounts are assessed and discussed by the teacher	2.78	2.40
7	The teacher uses words rather than mathematics in explanations whenever possible	2.48	2.13
8	The teaching order appears logical	2.83	2.30
9	The teacher anticipates the students' problems and sees the subject from their point of view	2.78	2.04

Statement describing teaching method	Mean score (N=143) Scale A Intrinsic worth	Scale B Degree of use
10 The teaching style encourages the interest of the student	2.83	1.91
11 To help you understand, films, filmstrips and filmloops are used as well as experimetnal demonstrations	2.51	1.56
12 Students' practical work is related to recent teaching lessons	2.92	2.52
13 The lessons are planned to make experimental and theory work run smoothly	2.82	2.25
14 Visits to outside events are sometimes arranged to broaden your knowledge of physics	2.57	1.53
15 The teacher uses lesson material from outside the examination syllabus when it is felt necessary	2.37	2.06
16 You are encouraged to work as an individual rather than as part of a large group of four or more	2.58	2.45
17 All students make their own notes and records of work covered in lessons	2.22	2.04
18 Some students make notes and circulate them to others	1.21	1.18*
19 Notes are made from dictation by the teacher	2.08	2.08*
20 Notes are made by copying from the board or overhead projector	2.28	2.30*
21 Duplicated lesson notes are issued on a short loan	1.68	1.19
22 Notes are made by a number of different methods	2.45	2.15
23 The teaching relates each new idea to a previously understood one	2.85	2.15
24 The teaching seems to be most suitable for the most able pupils	1.63	1.97
25 Students' practical work occurs in groups of four or more in the normal lessons	1.34	1.22*
26 Several teachers take the class, each one teaching a different topic	1.80	1.57
27 Homework relevant to teaching and practical lessons is set regularly	2.90	2.47

Statement describing teaching method	Mean score (N=143) Scale A Intrinsic worth	Scale B Degree of use
28 The special type of individual work for the A-level practical exam.is introduced into practical lessons towards the end of the course	2.36	2.07
29 The teacher encourages discussion and speculation amongst the students	2.81	2.22
30 The whole syllabus will not be completely covered, but the topics taught will have been thoroughly treated	2.01	1.90
31 Technical terms are used where appropriate, but otherwise the language is everyday English	2.77	2.67
32 Practical work is designed to help the student understand the knowledge from theory lessons	2.90	2.64
33 Each topic in the course is studied in depth	2.48	2.12
34 The teacher covers the syllabus quickly to leave as much time as possible for revision	1.75	1.78*
35 Individual or small group practical work takes place each week in a separate practical lesson	2.77	2.53
36 Students are helped and encouraged to revise for the A-level exam. in a planned way	2.73	2.21
37 Each lesson has an introduction, which tells you what the lesson is about, and a conclusion which summarises the lesson's content	2.32	1.27
38 Regular practice to develop a suitable style in answering exam. questions occurs in the second year of the course	2.90	2.34
39 All exam revision is done from the student's own notes	1.58	1.84
40 The whole syllabus will be covered but not all the topics will have been thoroughly treated	1.78	2.08

All differences between the responses on the two scales are significant at the 5% level at least (Wilcoxon, Appendix 5.11.2) except where indicated by an asterisk.

The difference in mean scores for Scales A and B identify the statements where there is least matching between the pupils' ideal and reality . However, the distributions of the scores on the short rating scales may be different, even if the means are similar. The most appropriate statistic to test for significant differences between the A and B scales appears to be the Wilcoxon test (Siegel, 1956). When this test is applied to the scale distributions, all pairs of statement scores are significantly different at the 5% level at least with the exception of those indicated in the table by an asterisk. Appendix 5.11.2 shows the pattern of responses to all 40 statements.

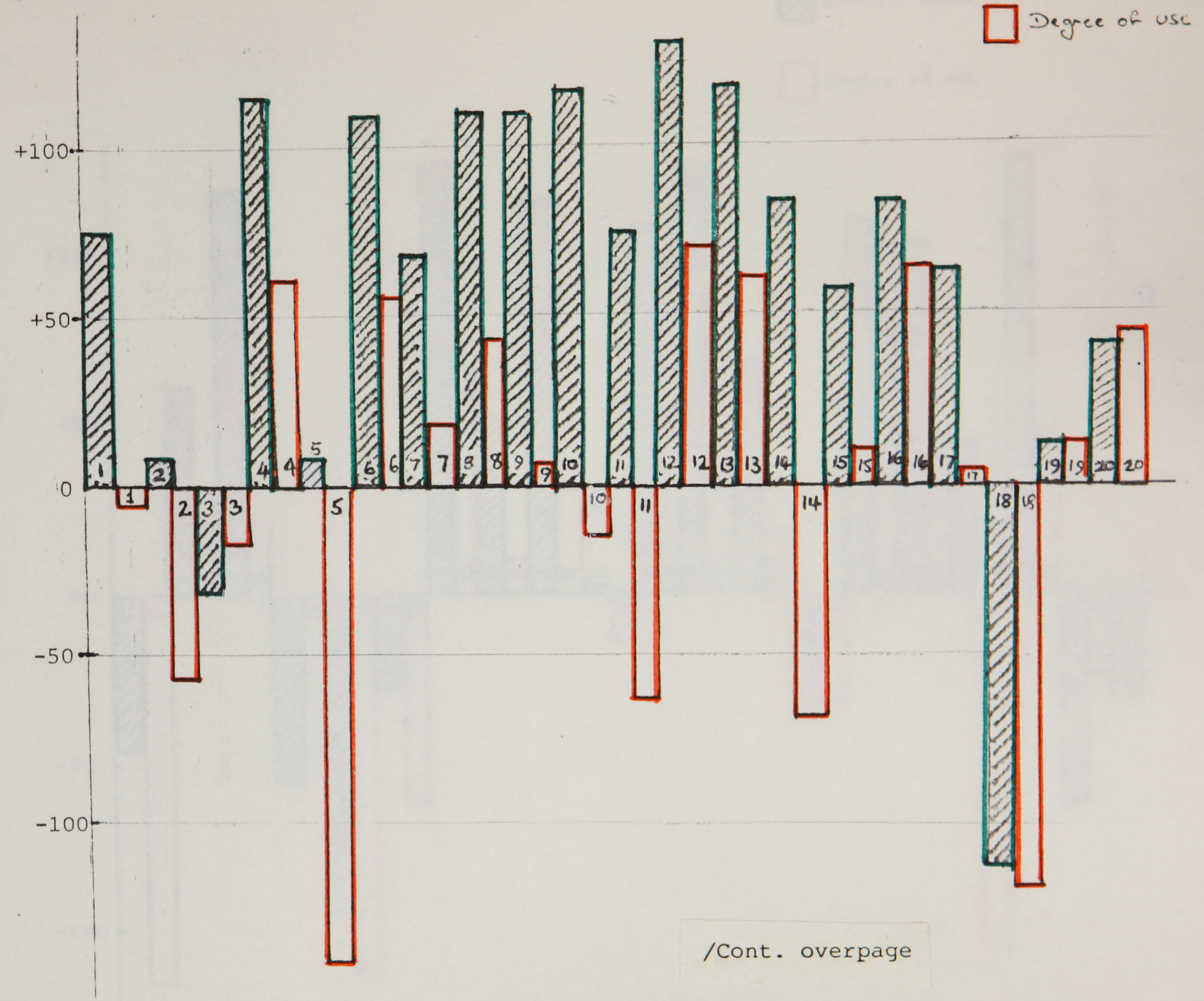
Figure 5.11.1 shows another presentation of the differences in responses to the statements. For both the 'intrinsic worth' and 'usage' versions of each statement, the excess number of pupils scoring '3' over those scoring '1' was calculated. Thus, a value of +50 indicates that 50 more pupils rate the statement '3' than rate it '1', while a value of -20 shows that a majority of 20 rate the statement '1' rather than '3'.

FIGURE 5.11.1 THE RESPONSE PROFILE

Popular method/
actually used

The number of pupils rating a statement '3' less the number rating it '1'.

Unpopular method/
not used



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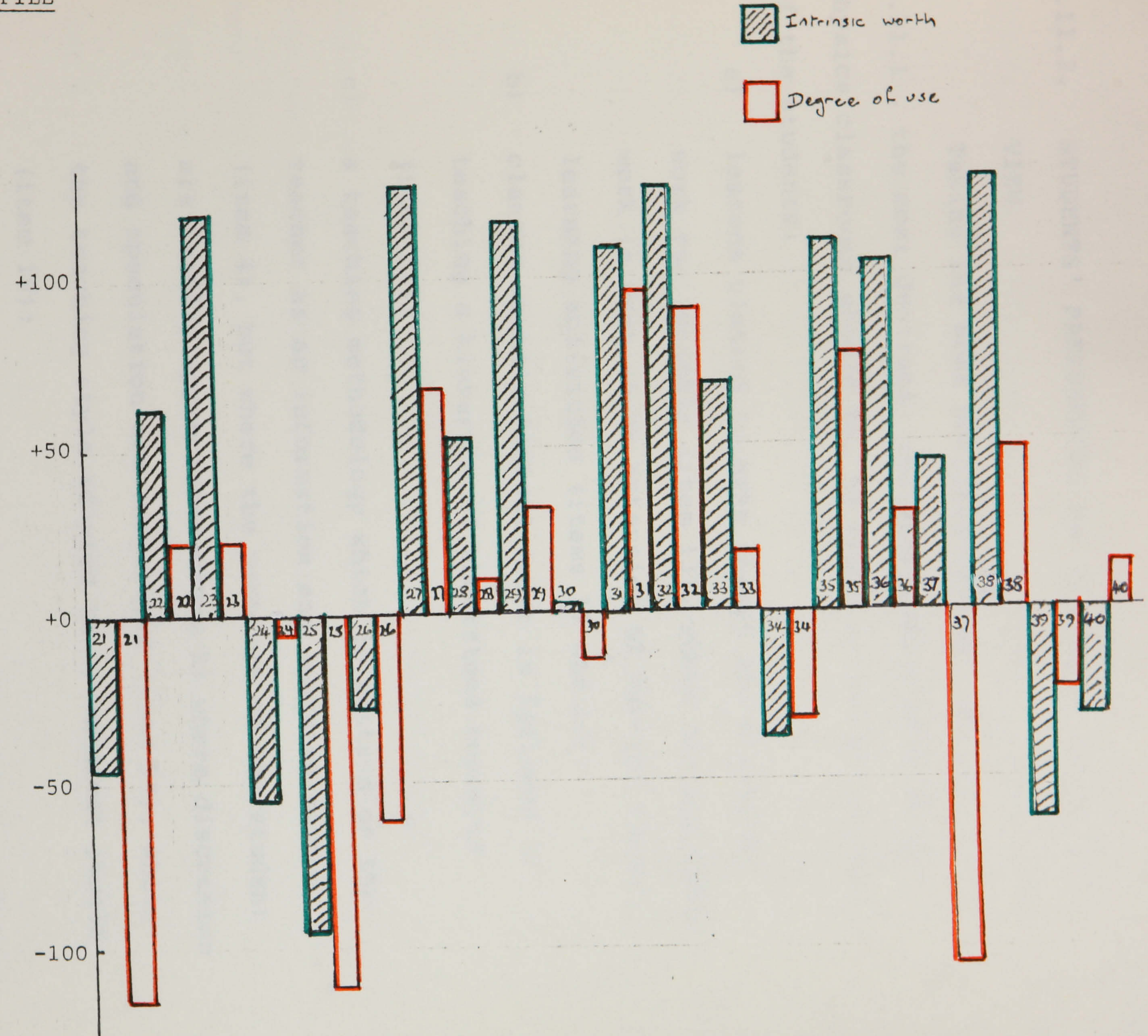
THE RESPONSE PROFILE

Popular method/
actually used

The number of pupils
rating a statement '3'
less the number rating
it '1'.

Unpopular method/
not used



5.11.2. STUDENTS' PREFERENCES AND REALITY - THE GLOBAL VIEW

Taking the most positive ratings from figure 5.11.1 , the most desirable characteristics of A-level physics classrooms should be, in terms of the preferences of the students:

a) lessons planned to make theory and practical work run smoothly (item 13), where the practical work is seen as an extension of current theory learning activities (items 12 and 13);

b) classes where a logical order is followed in teaching a hierarchy of understood concepts (item 23);

c) a teaching methodology which is centred on the teacher as an information and learning source (item 4), but where the problems of the student are readily appreciated (item 9) where discussion and speculation are encouraged (item 29), while the teaching style adopted is of interest itself (item 10);

d) classes where homework is set and marked regularly, (items 6 and 27) and, as the A-level examination draws near, where practice in examination techniques and help with revision is conducted (items 36 and 38).

The negative ratings from the profile show that these idealised lessons should <u>not</u> require:

e) the students to merely work through a textbook (item 3);

f) the syllabus coverage to be rapid at the expense of thoroughness (items 34 and 40);

g) the teaching task to be shared amongst two or more teachers (item 26);

h) the level of teaching to be directed towards the most able (item 24);

i) note-making to be the responsibility of particular groups of pupils, or to be achieved by the issue of duplicated notes (items 18 and 21), and

j) practical work to be conducted as part of normal teaching lessons (item 25).

Notable discrepancies between the students' preferences and their reports of reality are to be found with most items. Arguably, the more significant differences are:

item 1 - the relatively popular lecture-demonstration method is under-used;

item 8 - the actual teaching order is not always obviously logical;

item 9 - some teachers are unable to identify their pupils' needs;

item 10 - the teaching style itself might well be uninteresting;

item 11 - multi-media techniques are very neglected;

item 13 - a significant number of lessons are not well planned and smooth running (see also item 37);

item 14 - visits outside the classroom are seldom arranged;

item 23 - there is a likelihood that an understood concept hierarchy is not being built up;

item 29 - the teaching does not always allow for student discussion and speculation, and

items 36 and 38 - examination practice and revision might be insufficiently organised.

5.11.3. VALIDATING THE CHECK-LIST - STUDENT INTERVIEWS

An attempt was made to validate some of the check-list responses by incorporating items with an interview schedule (Appendix 5.11.3) used with a sample of the upper sixth-form students.

Six of the item responses could be checked directly. Table 5.11.2 shows the correlations between the interview and questionnaire scores. The interviews were conducted within three weeks of the completion of the questionnaires.

TABLE 5.11.2. SOME QUESTIONNAIRE AND INTERVIEW CORRELATIONS

Statement	Correlation between questionnaire and interview response (N = 24)	95% confidence interval for the correlation coefficient
7 The teacher uses words rather than mathematics in explanations whenever possible (Intrinsic worth)	0.55	0.19 - 0.78
21 Duplicated lesson notes are issued on short loan	0.49	0.11 - 0.75
26 Several teachers take the class, each one teaching a different topic (Intrinsic worth)	0.80	0.59 - 0.91
26 Several teachers take the class,each one teaching a different topic(Degree of use)	0.63	0.30 - 0.82
29 The teacher encourages discussion and speculation amongst the students (Intrinsic worth)	0.67	0.37 - 0.85
36 Students are helped and encouraged to revise for the A-level exam in a planned way (Intrinsic worth)	0.36	-0.05 - 0.67

The small size of the sample (24 students) limits this comparison technique to some degree, but it does provide a measure of validation. It was apparent from some of the comments at the interview sessions that the questionnaire administered a few weeks previously had made students think about their classroom environment more critically. It is not unreasonable to suppose that some shifts in opinion could have occurred in the intervening time if the students had reconsidered their positions. The result of this would have been a lowering of the correlation coefficient of course.

The responses to the 'multi-teacher' item 26 in degree-of-use form should be least susceptible to fluctuations in student opinion but these apparently, show only a moderate correlation. The students are being asked simply to state whether one or more teachers take the class. However, the four students who answered 'incorrectly' in the questionnaire had not included a second teacher who took the practical physics classes.

5.11.4. FACTOR ANALYSING THE SCALES

To identify conceptual patterns in students' preferences for learning, scale A responses were subject to a principal components factor analysis followed by varimax and oblique rotations of the factor axes (Section 2.9). Seventeen first order factors were identified accounting for some 68% of the total variance. Most of the factor scales comprised, at the most, just two highly loaded items. The search for psychologically meaningful groups of items then continued with increasingly severe limits imposed upon the factor solution. Finally, a three factor oblique rotation caused the most homogenous structure to appear. Appendix 5.11.4 shows the item-factor correlation matrix.

Factor scores were then computed by adding the statement scores for those items which showed the greatest correlation with a factor. Conceptual consistency as well as the magnitude of the statistical correlation was used as the criterion when allocating an item to a scale, (Appendix 5.11.5). The derived scales were taken to define three conceptual aspects of preferred classroom behaviour, namely (a) planned 'method' teaching, (b) notemaking procedures allied to rapid syllabus coverage, and (c) pupil-initiative teaching.

a) SCALE 1 - PLANNED 'METHOD'TEACHING:

This scale comprises the following 13 items, which are arranged in order of decreasing importance as defined by item-whole correlations (shown in brackets). The emphasis is on a planned environment and a sound, varied teaching method (Section 2.6).

37. Each lesson has an introduction, which tells you what the lesson is about, and a conclusion which summarises the lesson's content.(0.55)

8. The teaching order appears logical. (0.54)

14. Visits to outside events are sometimes arranged to broaden your knowledge of physics. (0.50)

29. The teacher encourages discussion and speculation amongst the students. (0.49)

11. To help you understand, films, film-strips and filmloops are used as well as experimental demonstrations. (0.48)

6. Individual homework and practical accounts are assessed and discussed by the teacher (0.43)

13. The lessons are planned to make experimental and theory work run smoothly. (0.41)

1. Teaching is by lectures with experimental demonstrations. (0.40)

36. Students are helped and encouraged to revise for the A-level exam in a planned way. (0.40)

35. Individual or small group practical work takes place each week in a separate practical lesson. (0.34)

10. The teaching style encourages the interest of the student. (0.33)

32. Practical work is designed to help the student understand the knowledge from theory lessons. (0.31)

12. Students' practical work is related to recent teaching lessons. (0.25)

b) SCALE 2 - NOTEMAKING/SYLLABUS COVERAGE PROCEDURES

This is a 10-item scale which measures lessons as information 'units' necessary for examination preparation. Item-whole correlations are in brackets.

19. Notes are made from dictation by the teacher. (0.50)

28. The special type of individual work for the A-level practical exam is introduced into practical lessons towards the end of the course. (0.48)

25. Students' practical work occurs in groups of four or more in the normal lessons. (0.47)

18. Some students make notes and circulate them to others (0.45)

34. The teacher covers the syllabus quickly to leave as much time as possible for revision. (0.45)

21. Duplicated notes are issued on short loan. (0.44)

40. The whole syllabus will be covered but not all the topics will have been thoroughly treated. (0.43)

20. Notes are made by copying from the board or overhead projector. (0.43)

26. Several teachers take the class, each one teaching a different topic. (0.42)

39. All exam revision is done from the students' own notes. (0.41)

c) SCALE 3 - PUPIL-INITIATIVE TEACHING

This 8-item scale emphasises pupil-initiated activities at the expense of some areas of traditional teacher direction.

2. Learning is by finding out by oneself after each new topic has been introduced by the teacher. (0.62)

17. All students make their own notes and records of work covered in lessons. (0.62)

20. Notes are made by copying from the board or overhead projector .(-0.56)

15. The teacher uses lesson material from outside the examination syllabus when it is felt necessary. (0.48)

22. Notes are made by a number of different methods. (0.43)

27. Homework relevant to teaching and practical lessons is set regularly. (0.41)

36. Students are helped and encouraged to revise for the A-level exam. in a planned way. (-0.37)

23. The teaching relates each new idea to a previously understood one. (0.31)

5.11.5. PREFERENCE SCALE RELIABILITY

The relatively low correlations reported in Appendices 5.11.4 and 5.11.5 suggest that reliability measures derived from variance estimates, such as the Cronbach Alpha coefficient, would themselves be only moderate. This indeed proves to be the case as table 5.11.3 shows.

TABLE 5.11.3. PREFERENCE SCALE RELIABILITIES

Scale	Cronbach Alpha (N = 143)	Test/ re-test (N = 27)
1 Planned 'method' teaching	0.61	0.79
2. Notemaking/syllabus coverage	0.55	0.71
3. Pupil-initiative teaching	0.53	0.80

(A test/re-test correlation of 0.48 is significantly different from zero at the 1% level)

The stability of the three scales is more effectively demonstrated by the test/re-test method. A group of 27 A-level physics students (not otherwise involved in the longitudinal survey)provided re-test data with an interval between the tests of two weeks. The correlation between the test and re-test scores gives the reliabilities in the final column of table 5.11.3.

5.11.6 INTER-SCALE CORRELATIONS

Table 5.11.4 shows that there is only one significant inter-correlation between the three preference scale scores. Girls who like planned, 'method' teaching are unlikely to prefer the pupil-initiative approach.

TABLE 5.11.4. PREFERENCE SCALE INTER-CORRELATIONS

Scale	Planned 'method' teaching	Notemaking/ syllabus coverage	Pupil- initiative teaching
Planned 'method' teaching		-0.04	-0.02
Notemaking/syllabus coverage	0.15		-0.06
Pupil-initiative teaching	-0.49**	-0.17	

**$p < 1\%$

Boys (N=108) above the diagonal; girls (N=35) below.

5.12. THE ATTITUDES OF SCIENCE TEACHERS

5.12.1. THE EFFECTIVE SCIENCE TEACHING QUESTIONNAIRE

Reference was made earlier in Section 2.8. to the 106-item teacher questionnaire developed by the Birmingham team of Taylor et al. (1970a and 1970b). This questionnaire had been used in four research studies, but only in the original Birmingham survey had a meaningful factor solution been obtained. The face validity of the findings from the Birmingham survey was such as to suggest that minor changes to the questionnaire design could sharpen the factor solution and give substantial reliability coefficients for the(possibly modified) scales.

Starting from the original eight factor solution, items which directly defined the factors were extracted. The additional items used by the Schools Council team in their abortive modification of the questionnaire (Galton, 1977) were then subject to a critical appraisal, as were the remaining original questionnaire items, with a view to adding suitably re-worded items to strengthen the original scales.

At this time, there was some doubt as to the availability of a statistical program capable of factor analysing a large number of variables. Thus, it was deemed prudent to restrict the number of questionnaire items to a maximum of seventy.

The additional items used in the Schools Council study tended to reflect the more general aims of this study, and, as no item statistics were readily available, it was decided to build upon the original eight factors from the item pool of the Birmingham survey only. From the latter, 66 items appeared to have significant statistical and psychological loadings on the eight factors. Four more items were constructed and added to reflect particular aspects of the current longitudinal attitude survey. It was not intended that these last four items should influence the factoral pattern of the items unduly. Indeed, it was possible to allocate the items amongst the existing factors. Rather, the hope was that these items might 'mark' some of the teacher factors in terms of some of the stronger pupil variables from the main survey.

An attempt was made to expand the apparently limited range of responses to the five-point item scales obtained in the Birmingham survey (Taylor et al., 1970a). Response category 1, 'not relevant', was replaced by category 2, 'unimportant'. The remaining categories were re-worded to remain compatible with a five-point scale.

The final form of the modified questionnaire appears in Appendix 5.12.1.

5.12.2. USING THE QUESTIONNAIRE

The physics teachers of all the fifth-form classes taking part in the longitudinal attitude survey were invited to complete questionnaires. In some of the survey schools, other science teachers of this pupil age range volunteered their assistance. An appeal for further participants was also made through the Association of Science Education (Pell, 1979).

In all, questionnaire data was obtained from 58 science teachers. This number can be compared with those of 58, 157 and 44, respectively, for the Birmingham, Scottish teachers' (Brown, 1974) and student teachers' (Eggleston and Dreyfus, 1977) surveys.

5.12.3. FACTOR ANALYSING THE RESPONSES

An initial principal components factor analysis showed 21 factors with eigenvalues greater than unity accounting for 83% of the total variance. Even after varimax and oblique rotations (Section 2.9.), few factors were easily interpretable. As there was strong theoretical justification for supposing an eight factor solution would be meaningful, the analysis was repeated with an eight factor structure imposed. For comparison purposes, six, seven and nine factor solutions were also obtained and the factor pattern matrices inspected after oblique rotation of the factor axes.

The eight factor solution comprised five clearly defined factors and three complex ones. The optimum analysis proved to be the seven factor one, with all the factors recognisable as describing meaningful teacher behaviours and comprising six or more strongly loaded items.

Table 5.12.1 shows the most strongly loaded item for each of the factor scales. The correlation given is between the item score and the factor score, where the latter is computed from the contributions of all seventy items.

TABLE 5.12.1. THE SEVEN TEACHING FACTORS - PRELIMINARY SOLUTION

Factor	Item that loads most heavily		Number of items
1	63.	Makes pupils aware of the broad linking concepts that run through science. (0.77)	16
2	51.	Plans the direction of his teaching with examinations, internal and external always in mind. (0.59)	9
3	27.	Changes curriculum and methods to keep up to date with developments in his subject and methods for teaching it. (0.71)	8
4	11.	Has patience in his dealing with pupils. (0.67)	10
5	20.	Has studied the philosophy and psychology of education. (0.75)	9
6	39.	Is confident and at ease when teaching. (0.57)	8
7	28.	Is clear and unequivocal in his personal relationships with pupils. (0.67)	8

The number of items for each factor was decided upon after inspecting the factor pattern matrix.

The seven sub-scale scores were then built by summing the individual item scores for that particular factor. The reliability of each scale was calculated as a Cronbach Alpha coefficient.

When items loaded similarly in statistical terms on more than one factor, and when it was difficult to make an allocation on psychological terms, several reliability coefficients would be calculated for the scales with and without the item before a final decision was made.

The items which it was found necessary to shift from one scale to another were generally those that loaded relatively lightly in the original factor analysis. However, a scale comprising a simple summation of item scores measures a slightly different psychological construct to that defined by the weighted scores from a 70-item factor sum. The method of summation was thus responsible for some change in the relative importance of the items in 'naming' the scales. In particular, the scale derived from factor 7 lost four of its original items but gained in internal consistency while still demonstrating a psychological homogenity.

The final solution is shown in table 5.12.2. The full scales appear in Appendix 5.12.2.

TABLE 5.12.2. THE SEVEN TEACHING FACTORS - FINAL SOLUTION

Scale		Item that correlates most strongly with (scale score - item score)	Number of items	Reliability (Alpha)
1	63.	Makes pupils aware of the broad linking concepts that run through science. (0.77)	13	0.89
2	22	Is a competent performer of any skills which are needed in teaching. (0.52)	8	0.74
3	58.	Encourages open-ended discussion. (0.64)	10	0.85
4	37.	Tries to stimulate pupils to think for themselves about science. (0.72)	9	0.80
5	20.	Has studied the philosophy and psychology of education. (0.65)	10	0.84
6	16	Can devise experiments which involve pupil participation in learning. (0.74)	5	0.78
7	39.	Is confident and at ease when teaching. (0.59)	11	0.79

The correlations of all 70 items with the scale scores appear in Appendix 5.12.3.

5.12.4. DESCRIPTION OF THE SEVEN SCALES

Scale 1. Expansive teaching of the processes of science

The major items on this scale express aspects of the process of science. It is felt important that pupils understand the positions of facts , theories and linking concepts in science (items 63, 60, 40 and 66). The impact on the environment is to be appreciated (items 25 and 41). The teacher is expected to show by example the broad, expansive view of science, achieving this by a balanced programme of practical work (item 64); by being prepared to move outside an examination syllabus (item 57); by setting tests that demand application abilities (item 56); by being willing to consider new evidence (item 13), and by being prepared to collect such information from outside a particular discipline (item 19).

Scale 2. Competent, exam-oriented science teaching

The thread running through this dimension of the teaching process is that of a concern with examinations. The latter are, for the most part, formative teaching aids (items 59 and 68) but teaching might be subsumed to the needs of examinations (item 51).

The scale has a bi-polar appearance. Its second dimension, which does not at first sight appear to be directly related to examination oriented teaching, is that of competent teaching (item 22), which draws upon the advice of colleagues when necessary (item 43). The implications in science teaching are that suitable text-books will be provided (item 29) by a teacher who is skilful in his use of equipment (item 30) while teaching 'career scientist' pupils (item 36).

Scale 3. Pupil-oriented science teaching

The involvement of pupils in learning is the main factor expressed by this scale. Science as such seems to be of less importance than the need for pupils to actively participate in lessons.

The active involvement of pupils (items 58, 31, 49 and 32) makes it natural for the learning style to stem from the pupils own interests (item 45). When material is introduced by the teacher, there is an obligation to explain its importance (item 54).

Although there might be a certain open-ended nature to some of the learning (item 58), the teacher structures the classroom with up-to-date scientific knowledge and teaching methods (items 45 and 5). The infusion of new ideas requires a suitable provision of materials for the active pupil learners. This is accomplished by the teacher's own sources (item 46) and by involving the pupils themselves (item 32).

Perhaps as a consequence of the significant pupil activity, the teacher frequently revises earlier work (item 47).

Scale 4. Interest-in-science teaching

This scale seems to measure the need to develop an interest in science in the pupils (items 37 and 4). The means of doing this is to patiently start from the pupils' viewpoints and develop new learning outwards from this (items 11, 69 and 4). This approach leads to an understanding of science (item 53) which allows pupils to think for themselves (item 37). For the teacher to be able to develop these thinking skills in the pupils, he needs to have a wide ranging competence in science and science teaching (items 8, 9 and 67).

Scale 5. Learning-theory based teaching

This scale recognises the theoretical base of teaching and its implications for consistent classroom practice (items 20 and 38). To acquire or up-date teaching theory, in-service training is taken (item 18). Teacher training suggests an organised methodology of lesson planning(item 12); an approach to pupil problem solving and motivation (items 17 and 48); a method of lesson presentation using audio-visual techniques (item 6), and an appreciation of evaluation techniques (items 33, 14 and 35).

Scale 6. Learning in a planned, experimental laboratory

Here the experimental method of science learning is being advocated (item 16) as against a 'numbers in a formula' approach (item 65). A modern view of the curriculum and teaching methodology is held (item 27).

Each lesson is a clear, planned learning 'unit' (item 70). Adequate lesson preparation is necessary for 'unit' and experimental learning (item 44).

Scale 7. Desirable, disciplined pupil relationships

Aspects of the teacher-pupil relation are expressed by this scale. Overall, a satisfactory pattern of relationships leads to the teacher viewing his position as one of confidence and ease (item 39). In particular, the pupils know clearly where they stand (item 28); are aware of a structure of discipline within the classroom (items 42 and 3), and are treated appropriately as individuals (items 23, 52, 55, 21 and 34).

The teacher is in control of the classroom in a firm but sympathetic manner (items 21, 10 and 26).

5.12.5. SCORES ON THE SCALES

A set of seven scale scores was calculated for each of the 58 teachers. The mean scale scores per item are displayed in table 5.12.3. This procedure allows the most highly rated attributes to emerge.

TABLE 5.12.3. SCALE MEAN SCORES

Scale	Mean score	Number of items	Mean score per item	Standard deviation per item
1. Processes of science	50.40	13	3.88	0.55
2. Competent exam-oriented	30.36	8	3.80	0.54
3. Pupil-oriented	33.74	10	3.37	0.62
4. Interest-in-science	37.41	9	4.16	0.47
5. Learning theory based	33.29	10	3.33	0.61
6. Planned experimental lab.	18.74	5	3.75	0.68
7. Disciplined pupil relationships	46.78	11	4.25	0.42

The most preferred behaviours of science teachers are 'interest-in-science' teaching (Scale 4) in a 'disciplined' classroom (Scale 7). Not only do these two scales show the highest mean scores, they also the greatest measure of agreement between the teachers as the small standard deviations indicate.

There is only moderate support for 'pupil-oriented science teaching' (Scale 3) and 'learning-theory based teaching' (Scale 5). However, there is evidence of more disagreement amongst the teachers in these instances, as indicated by the larger standard deviations.

The worth of 'learning in a planned, experimental laboratory' (Scale 6) causes the greatest disagreement with mean scores ranging from 1.40 to 4.80 per item.

5.12.6. INTER-CORRELATION OF THE SEVEN SCALE SCORES

Scale scores were inter-correlated for the 58 teachers to give the matrix of table 5.12.4.

TABLE 5.12.4. SCALE INTER-CORRELATIONS

	Correlation with Scale					
Scale	1	2	3	4	5	6
2	36**					
3	65**	27*				
4	53**	31*	41**			
5	59**	27*	58**	38**		
6	35**	24	50**	11	54**	
7	43**	42**	40**	42**	43**	33*

Decimal points are omitted
** $p < 1\%$, * $p < 5\%$

A factor analysis of the seven scale scores, performed with an oblique rotation of the factor axes, showed two factors correlating positively at 0.47 accounting for 64% of the variance.

The first factor is most strongly associated with 'interest-in-science','processes of science' and 'disciplined relationships'. The second is a measure of 'planned, experimental laboratory' teaching and 'learning-theory based' teaching.

CHAPTER 6

TEST RESULTS FOR THE TEACHERS

6.1. SOME TEACHER STEREOTYPES

With seven scale scores on the Effective Science Teaching Questionnaire (Section 5.12) available for each of 58 teachers, it was possible to test for the existence of 'natural types' of science teacher by using the technique of cluster analysis (Section 2.9).

Employing the P.M.M.D. program (Youngman, 1975), it was found that cluster solutions comprising more than four groups were, to varying degrees, functions of the order in which the teacher data was read by the program. However, consistent four group solutions were obtained regardless of the data input order. These groups appear in table 6.1.1. where the mean scale scores are in standard form.

TABLE 6.1.1. FOUR BROAD TEACHER CLUSTERS

Scale	Mean standardised score on scale			
	Group A (N = 3)	Group B (N = 41)	Group C (N = 9)	Group D (N = 5)
1. Processes of science	1.41**	-0.20**	1.36**	-1.70**
2. Competent, exam-oriented	1.24	-0.26**	1.05**	-0.50
3. Pupil oriented	-0.23	-0.07	1.43**	-1.86**
4. Interest-in-science	1.26*	-0.37	1.29 **	-0.05
5. Learning-theory based	-0.49	-0.15	1.47**	-1.11**
6. Planned, experimental lab.	-2.01**	0.15*	1.00**	-1.83**
7. Disciplined pupil relationships	0.41	-0.15	1.10**	-1.00

** p < 1%; * p < 5%

An asterisk indicates a significant difference between a group or cluster mean and the rest of the scores.

Group A

The three teachers in this group believe strongly in the worth of teaching the processes of science. An interest-in-science approach should be developed but the planned, experimental laboratory technique is unpopular. Acknowledging the nature of science, these teachers nevertheless do not feel that learning should be achieved through experimental work. This is the teacher-centred, interest-in-science group.

Group B

Very much the major group, these teachers have relatively low opinions of the processes of sciences, exam-orientation and interest-in-science teaching approaches but do favour the idea of the planned, experimental laboratory.

Considerable care must be exercised in interpreting the mean scores of this group, however. There is no real control group or ideal population against which group B scores can be compared. While it is reasonable to draw some meaningful conclusions from the mean scores of groups A, C and D, these comprise just 17 teachers from a sample of 58. The nature of the cluster analysis means that the 41 teachers or group B are being compared with only 17 others. Ideally, the solution lies in a much larger sample size, but, in reality, a further clustering of the group B teachers alone is suggested. This calls for a separate group B analysis (see below), bearing in mind the difficulty in interpreting higher order solutions when a full cluster analysis is run.

Group C

This is a most unusual group of 9 teachers. The mean scores on all scales are significantly higher than the other 49 teachers'. If all-round high scale scores represent the criteria to which all science teachers should aspire, which is arguable, then group C teachers are the exemplars of preferred teaching behaviour.

Group D

Teachers in this group show very traditional and conservative attitudes. Science teaching is not seen as being particularly concerned with what science is about; neither is it seen as an activity demanding much pupil involvement. Teaching is perceived as pragmatic, rather than theory-based. Given an expectation of a minimal pupil role, it is not surprising to find the experimental laboratory poorly rated. To these teachers, teaching science appears to be little more than a routine task or chore. These are the worker-teachers.

The sub-divisions of Group B

The cluster analysis when Group B only were input strongly suggested a four-cluster solution. This was found to be independent of the order of data input. Mean scores of the four sub-groups appear in table 6.1.2.

TABLE 6.1.2. FOUR SUB-DIVISIONS IN GROUP B

Scale	Mean standardised scale score			
	Group B_1 (N = 10)	Group B_2 (N = 7)	Group B_3 (N = 10)	Group B_4 (N = 14)
1. Processes of science	-0.01	0.97*	0.12	-0.57*
2. Competent, exam-oriented	-0.82**	-0.74	0.32	0.72**
3. Pupil oriented	-0.69*	0.25	1.16**	-0.46
4. Interest-in-science	-0.32	0.88	0.40	-0.50
5. Learning-theory based	0.05	-0.03	0.99**	-0.73**
6. Planned, experimental lab.	-1.18**	1.03**	-0.22	0.49*
7. Disciplined, pupil relationships	-0.37	-0.69	0.27	0.42

** $p < 1\%$; * $p < 5\%$

An asterisk indicates a significant difference between a group or cluster mean and the rest of the scores.

It is misleading to draw conclusions as to the characteristics of the sub-groups from the scores of table 6.1.2. alone. Reference must be continually made to the position of group B in table 6.1.1. before meaningful interpretations can be made.

As an example, take the performance of group B_1 on scale 6. Apparently these teachers do not rate at all highly learning in a planned, experimental laboratory. However, table 6.1.1. shows that group B teachers overall do significantly prefer this learning method, so the rejection shown by Group B_1 is very much a relative rather than an absolute one. It is reasonable to assume that the dislike shown by groups A and D towards this style of teaching is much the stronger.

Group B_1

In some respects, this group has similar attitudes to those held by Group D. Pupil involvement in lessons and the planned, experimental laboratory are lowly rated. While no over-concern is expressed about examinations, the teaching does not particularly cultivate a knowledge of the processes of science, neither does it aim to develop 'interest-in-science' attitudes.

This group of teachers might be said to subscribe to the style of a teacher-centred, didactic exposition of a neutral science.

Group B_2

The process of science and the planned, experimental laboratory are highly rated by this group. Exam-oriented teaching is not well thought of. As there is no strong commitment to learning-theory based teaching, which otherwise might give a theoretical link between teaching by experiment and the nature of science subject material, it seems appropriate to call this group 'science intuition' teachers.

Group B_3

The two dominating characteristics of these teachers are the beliefs that science teaching must involve the active participation of pupils and that a clear teaching theory should be followed. This is the pupil-centred teacher group.

Group B_4

The group characteristics here are the positive ones of exam-oriented teaching with learning in the planned, experimental laboratory. Negative ratings are given to teaching the processes of science, the need to develop a pupil interest in science and the need for a learning theory in teaching. These teachers are the 'pragmatic attainment seekers'.

The seven teacher stereotypes identified by this analysis are summarised in table 6.1.3.

TABLE 6.1.3. TEACHER STEREOTYPES

Type	Description	Number in category
A	Teacher-centred, interest-in-science	3
B_1	Teacher-centred, didactic expositors of a neutral science	10
B_2	Science intuition	7
B_3	Pupil-centred, theory-based	10
B_4	Pragmatic, attainment seekers	14
C	Exemplars	9
D	Worker-teachers	5

6.2. USING THE SCALES TO COMPARE TEACHER POPULATIONS

The 58 science teachers were drawn from, arguably, two different populations. The first group comprised 33 physics teachers whose physics classes were taking part in the longitudinal attitudes survey. The remaining 25 teachers were drawn from all three science disciplines and had volunteered their help as part of a 'general' science teacher population.

Table 6.2.1. shows mean scale scores for the

two teacher groups.

TABLE 6.2.1. DIFFERENCES BETWEEN TEACHER POPULATIONS - SCALE SCORES

Scale	Mean scale score (standard deviation)	
	Physics survey teachers (N = 33)	'General' group (N = 25)
1. Processes of science	48.76 (7.29)	52.56(6.34)*
2. Competent, exam-oriented	29.82 (4.88)	31.08(3.44)
3. Pupil oriented	31.82 (5.31)	36.28(6.36)**
4. Interest-in-science	35.88 (4.12)	39.44(3.40)**
5. Learning-theory based	31.79 (5.00)	35.28(6.84)*
6. Planned, experimental lab.	18.39 (3.31)	19.20(3.51)
7. Disciplined, pupil relationships	46.58 (4.63)	47.04(4.66)

** $p < 1\%$; * $p < 5\%$ (t-test)

The significant differences between some of the mean scores support the hypothesis that two different population groups exist here. The survey teachers are less inclined to rate highly the pupil oriented, interest-in-science and learning-theory based styles. They also seem more suspicious of the worth of the processes of science style.

The differences between the two teacher populations are confirmed by a breakdown of the teacher stereotypes previously reported as table 6.2.2. shows. The physics survey teachers are more likely to be found in the 'didactic expositors' or 'pragmatic attainment seekers' groups, although differences cannot be tested for significance because of the small sub-cell numbers.

TABLE 6.2.2. DIFFERENCES BETWEEN TEACHER POPULATIONS - STEREOTYPES

	Teacher type	Number in category: Physics survey group (N = 33)	'General' group (N = 25)
A	Teacher-centred, interest-in-science	1	2
B_1	Didactic expositors	8	2
B_2	Science intuition	4	3
B_3	Pupil-centred, theory based	3	7
B_4	Pragmatic, attainment seekers	9	5
C	Exemplars	4	5
D	Worker-teachers	4	1

6.3. CONCLUDING REMARKS

The results presented here successfully illustrate the application of factor and cluster analysis techniques to teacher attitudes.

It is acknowledged that the statistical technique of factor analysis is of questionable validity when the number of items analysed exceeds the number of respondents (Youngman, 1979), but as the main objective of extracting homogeneous groups of items from an initial correlation matrix has been achieved, the worth of the factor analysis method as an initial means of collecting together the most highly inter-correlated items has been demonstrated. The seven scales of effective science teaching behaviour are of sufficient stability to show substantial internal consistency (table 5.12.2.) even with a teacher sample of only moderate size. Whatever the outcome of the factor analysis, the seven scales and the item-scale correlations have a reality, which is independent of the techniques used to interpret the initial correlation matrix.

The existence of the seven scales confirms that it is possible to identify patterns of effective behaviour amongst English science teachers. When comparing the seven scales with those from the Birmingham Project (Taylor et al., 1970a), only scales 1 and 7 share substantially the same items. It is interesting to note, however, that the Birmingham team did conceptualise two further scales as 'impersonal, evaluative science teaching' and 'pupil autonomy science teaching'. These same concepts arise in the present research in the form of scales 2 and 3, respectively, although they have been defined by generally different items.

While the statistical and psychological soundness of the seven scales has been demonstrated, where does this leave the original 'Birmingham' scales? The latter were derived from an analysis of more than 100 items. A re-analysis of the data collected in the Birmingham survey using the restricted number of items would, arguably, give a quite different factor pattern, perhaps more closely approximating to the seven factor solution of the present work.

The typological analysis, as summarised in tables 6.1.1 and 6.1.2 is instructive, if not definitive. It strongly supports Brennan's call (Sections 2.8 and 2.9) for the use of cluster analysis in educational research. The seven stereotypes described in table 6.1.3 are likely to be, in part, a function of the size of this particular survey. Another 100 teachers in the sample, say, could well have introduced further stereotypes. Even so the science-intuition teachers, the worker-teachers etc., would be expected to remain. Thus, table 6.1.3 can be thought of as displaying the minimum number of science teacher stereotypes, as far as this can be measured by perceptions of 'best classroom practice'.

This raises the whole question of validity. Validity of the seven sub-scales and validity of the clusters. For the present, the case must rest on the conceptual, face validity of the scales as a composite of the items comprising them, giving due weight to the relative item correlations with the total score. If it is possible to answer positively the question, 'does this combination of items express a concept that is recognisable as a characteristic of a science class room?' then the scale has validity, even if it cannot be expressed in quantitiative terms.

The same criterion must be applied to the clusters or stereotypes. Are these recognisable as teacher models? To each of these categories, can real, practising science teachers be allocated? For instance, knowing teachers X, Y and Z, can they be seen as occupying their characteristic positions amongst the seven categories? If the answer is that teachers X and Y can, but that teacher Z is part of A and part of B_2, then this indicates that the stereotyping of table 6.1.3. is still coarse and a larger sample size is needed for refinement. However, the fact that a meaningful judgement can be made between the seven stereotypes is evidence of the validity of the latter.

It is tempting to compare teachers' scale scores with observed classroom behaviour as an indication of scale validity. However, by itself this might not be sufficient. It does not follow that a teacher's expressed preference for a certain style, as measured by the Effective Science Teaching Questionnaire, is indeed borne out in practice in the real classroom. If the modified questionnaire is used in a research design including the structured observation schedule (Appendix 5.4.3A) and the pupils' perceptions check-list (Appendix 5.4.1), a series of inter-validity tests could be performed. In the present research, some measure of validity of the scales is pursued by seeking significant associations between scale scores and pupil outcomes (Section 7.9 and Appendix 6.3.1).

The demonstration of the existence of clusters of science teachers leads to a further, perhaps more convincing, explanation of the differences in the results of the Birmingham survey and the present one. Any sample of 58 teachers drawn from the population of science teachers as a whole is most likely to result in differential weightings of the stereotype groupings. A factor-analysis pattern of responses from a teacher group predominantly comprised of pupil centred, theory-based teachers (type B_3), would be expected to be quite different to a teacher grouping which, for the most part, was made up of pragmatic attainment seekers (type B_4).

The question is now raised as to what degree are the seven scales and the typological structure they imply a function of the heterogeneity of the sample? Within the limits of the design of the research reported here, it is not possible to answer this with much certainty. The conclusions drawn from any social science research must be heavily qualified by the nature of the sample, whether random or not, and the dangers of generalising results are well known (Shipman, 1972). The consistency of the seven scales in the present research, and the broad similarity in meaning that four of these scales show with the Birmingham study, suggests that the underlying structure that supports science teachers attitudes is starting to emerge. To reveal this structure more clearly, a sample of much increased size is highly desirable, preferably of a random nature. The Association for Science Education has recently introduced an innovation into their Annual General Meeting (A.S.E., 1980) which could make such data collection easier.

Within the limits set by the size of the sample in the current research, valid interpretations of the results can still be usefully made. The most desirable classroom behaviours, it is generally agreed, are those of firm but sympathetic discipline in which the teacher strives to develop the pupils' interest in science. The correlation matrix of table 5.12.3 shows that 'interest-in-science' correlates with all the other scales except 'planned, experimental laboratory learning'. There is evidence here that for some teachers (i.e. teacher stereotypes), learning-by-experiment has only a minor part to play in teaching fifth-form physics. The cluster analysis identifies the teacher-stereotypes (A, B_1 and D) who are loathe to use an experimental approach. The emergence of a specific factor linking planned, experimental laboratory teaching with 'learning theory' suggests that teachers with the soundest training in education are most likely to teach physics by experiment.

The physics survey teachers (table 6.2.2.) tend to be over-represented in the stereotype clusters B_1 and B_4. They are less likely to teach for interest in science or to subscribe to the importance of the philosophy and nature of science than are the general 'control' teacher group, which did include some of the more active members of the Association for Science Education who responded to the appeal for contributors. However, some of the physics survey teachers do rate imaginative, interest-in-science teaching highly and cause the generalisation of the Birmingham team (Taylor et al., 1970a), that science teachers are somewhat narrow and conservative, to be suspect when applied in the present study.

The ability of the Effective Science Teaching Questionnaire to distinguish between different populations points to its potential value in curriculum research, after further validity tests. The science teacher stereotype variable would be introduced as a variable in innovatory research and evaluation studies to clarify the interaction between teachers, processes and pupils (Galton, 1979; Gonzalez and Gilbert 1980). One would then envisage future curriculum projects having designs built in to encourage their assimilation into the teaching programmes of a wide range of teacher stereotypes and avoiding the mis-match which causes an innovation to be rejected (Booth, 1975).

A further application would be in the training and re-training of teachers. The use of the Questionnaire as a pre- and post-test would be part of the evaluatory feed-back of a science education course. As student teachers might not be distributed across the entire teacher type spectrum, and following the abortive attempt of Eggleston and Dreyfus (1977) to obtain a meaningful factor solution with a sample of students, it would be prudent to use the scales as defined in the present research rather than to search for a specific student-teacher factor pattern.

6.4. TESTING THE HYPOTHESES FOR THE TEACHERS

Three teacher hypotheses appear in Chapter 3. Two of these are

Physics teachers responses to a form of the Effective Science Teaching Questionnaire

3.4a) reveal meaningful factors of behaviour

3.4b) permit the establishment of a typology of teachers

The evidence that seven reliable scales can be obtained (Chapter 5) strongly supports hypotheses 3.4(a), which is retained.

The appearance of the seven teacher stereotypes in Chapter 6 supports hypothesis 3.4(b), which is also retained.

The third teacher hypothesis is tested in Section 7.13 (p.437).

CHAPTER 7

TEST RESULTS IN THE FIFTH-FORM

7.1. INTRODUCTION

The results obtained with the scales of Chapter 5 are described in succeeding Sections of this Chapter for the fifth-formers. There is an inevitable overlap with corresponding Sections of the earlier Chapter. Frequency distributions and other item statistics necessary for data reduction, which appear in Chapter 5, are further analysed in terms of criterion outcomes of attainment and enjoyment (Sections 7.2. to 7.8.). Scores on all the variables are then used in Sections 7.9. to 7.12. to investigate the nature of the Eysenck Lie scale, the characteristics of A-level physics choosers and rejectors, a typology of physics classes and a typology of pupils. In Section 7.13., the research hypotheses are tested for the whole sample of pupils, and brief reference is made to the difficulty of applying this procedure to the relatively diverse pupil stereotype groups.

7.2. PHYSICS ENJOYMENT IN THE FIFTH-FORM

7.2.1. ATTITUDE DIFFERENCES BETWEEN THE SEXES

Scores on the four attitude sub-scales were broken down by sex and fifth-form examination (i.e. G.C.E. or C.S.E. physics). Table 7.2.1 shows that there are significant sex differences on three of the four attitude dimensions for the G.C.E. pupils, all favouring the boys.

Inter-correlations between sub-scale scores (see earlier table 5.2.9.) can be explored for boys and girls separately. The pattern of inter-correlations is similar in all respects bar one: learning-by-experiment scores correlate much more positively with the other three attitude sub-scale scores for girls than they do for boys (table 7.2.2). Indeed, for the boys, there is even a negative, though insignificant association between learning-by-experiment and enjoyment.

TABLE 7.2.2. SEX DIFFERENCES IN THE INTERPRETATION OF 'LEARNING BY EXPERIMENT'

Sub-scale	Correlation between learning by experiment and sub-scale scores: Boys (N=537)	Girls (N=204)
Enjoyment	-0.07	0.18**
Committed physicist	0.01	0.21**
Problem-solving	0.13**	0.35**

** $p < 1\%$

TABLE 7.2.1. MEAN SCORES ACCORDING TO SEX AND EXAMINATION

Sub-scale	Mean score (standard deviation)					
	Boys (G.C.E. and C.S.E.) N = 537	Girls (G.C.E. and C.S.E.) N = 204	Boys (G.C.E.) N = 366	(Girls(G.C.E.) N = 151	Boys (C.S.E.) N = 113	Girls (C.S.E.) N = 26
Committed physicist	18.70(5.74)**	17.24(5.07)**	20.02(5.49)**	17.97(5.12)**	16.32(5.14)	16.35(4.75)
Enjoyment	28.12(6.03)**	26.22(5.52)**	29.81(4.32)**	27.36(5.06)**	25.17(6.55)	24.42(5.68)
Learning by experiment	22.07(3.60)*	21.35(3.92)*	21.88(3.67)	21.34(3:29)	22.58(3.10)	21.65(3.72)
Problem-solving	16.18(3.49)**	15.35(3.32)**	16.87(3.17)**	15.80(3.04)**	14.84(3.60)	14.35(3.30)

58 boys and 27 girls did not, in the event, sit an examination
Sex differences are $*p < 5\%$, $** p < 1\%$

When no distinciton is drawn between examination course, boys show superior attitudes on all the sub-scales

The weak relationship between learning-by-experiment and the other attitude variables, for the boys, suggests that positive affective outcomes from physics classrooms do not accompany a preference for doing practical work and learning from direct experience of concrete concepts. For the girls though, the most favourable attitudes, especially the problem-solving aspect of the subject, are related to a preference for the more concrete, learning by experiment.

7.2.2. ATTITUDES AND ATTAINMENT

The G.C.E. O-level physics grade was taken as the attainment measure. The six grades from 'A' to 'Unclassified' were scored from six to one, respectively.

The four attitude scale scores were then used to predict the O-level grade score by means of multiple regression (Section 2.9). This technique allows a linear equation to be built up from the four attitude variables. [Each variable is assigned a weighting coefficient, called a beta-weight, in the construction of the equation. Thus, the greater the beta-weight, the more important the variable in explaining the variation in the physics grade scores].

The beta-weights of table 7.2.3 show clearly the strength of the enjoyment scale as a predictor of academic success.

Once the regression equation is composed, the grades predicted from it can be compared with the real grades achieved in the examinations. The correlation between the real and predicted grades is no more than 0.34, which shows that very little is to be gained by adding any additional variables to 'enjoyment' when predicting achievement, as the simple correlation is 0.32 by itself.

TABLE 7.2.3. PREDICTING O-LEVEL ACHIEVEMENT

Sub-scale	Beta-weight	Simple correlation between sub-scale score and exam grade (N = 517)
Enjoyment	0.24	0.32
Learning-by-experiment	-0.10	-0.08
Problem-solving	0.10	0.24
Committed physicist	0.04	0.26

A correlation of 0.09 is significant at the 5% level

Girls have been shown in table 7.2.2 to possess a distinctive attitude pattern. This might be supposed to lead to different predictive regression equations and hence beta-weights for the two sexes. To some degree, as table 7.2.4 shows, this is indeed the case.

TABLE 7.2.4. SEX DIFFERENCES IN PREDICTING O-LEVEL ACHIEVEMENT

	Boys (N = 366)		Girls (N = 151)	
Sub-scale	Beta-weight	Simple correlation between score and grade	Beta-weight	Simple correlation between score and grade
Enjoyment	0.18	0.32	0.43	0.39
Learning-by-experiment	-0.09	-0.09	-0.12	-0.04
Problem-solving	0.10	0.26	0.07	0.23
Committed physicists	0.10	0.30	0.10	0.22
Multiple correlation	0.35		0.41	

Significant correlations at the 5% level are 0.10 and 0.16 for boys and girls, respectively

The difference between the girls' and boys' predictive equations can be seen to lie in the strength of the dependance upon the enjoyment variable. While enjoyment of physics lessons is the strongest single attitudinal predictor for both boys and girls, the relationship for the latter is much the more powerful. In other words, if girls get a good 0-level grade, it is more likely that they enjoy the subject.

Again, the enjoyment variable by itself is almost as strong a predictor of physics attainment as is the multiple regression equation using all four variables.

Pupils taking the C.S.E. physics examination show very low correlations between the attitudinal variables and attainment, with insignificant beta-weights. Consequently they have been omitted from the sex/attainment breakdowns.

7.2.3. CONCLUDING REMARKS

Successful modifications have been made to earlier versions of the Science Attitude Questionnaire. On what is now a more concise scale, four distinct affective attributes have been identified, which compare very favourably in internal homogenity with the earlier Schools Council form of the test. What is more, tests of validity have substantiated the four attitude factors, which demonstrates furtherthe theoretical soundness of this modified scale in comparison with its forerunners.

The finding that boys generally display the superior attitudes is consistent with earlier research

(Section 2.4). An original and intriguing result , however, is that learning-by-experiment appears to reinforce positive attitudes towards physics for girls but has little effect for boys. Pont (1970) has pointed out that girls tend to dislike 'thinking' science that takes place in an ambiguous or open-ended setting. Kelly (1981) gives anecdotal evidence to support this hypothesis: girls tend to be more comfortable in a structured environment. Interpreting the findings of the current research, it appears that the girls who like physics also like to learn by handling equipment and performing concrete learning tasks in a hypothesised structured or guided discovery situation. In Section 2.4 , the picture drawn by Kelly (1975) is one of girls in the secondary school driven to rote learning in a difficult subject. It now appears that girls who reach the fifth-form still enjoying physics have recognised the nature of the subject and the part that experimental work plays in it. With the sympathetic support of their teachers, it seems that some girls at least wish to take a positive role in their own learning.

The high intercorrelation between the enjoyment, committed physicist and problem-solving sub-scales makes it tempting to sum these three scores to obtain a composite measure of 'physics identification'. However, this could be resisted for two reasons. Firstly, the high reliability of the enjoyment scale alone (0.88) means that little is gained in statistical terms by the summation ('physics identification' has an internal consistency of 0.92).

Secondly, having identified the three distinct psychological concepts, it would be at a sacrifice of this precision if an analysis should be conducted in terms of the composite attitude dimension. This is not to say that the latter is a worthless entity, but it is recommended that the summation of sub-scales should be employed as a means of data reduction only after an investigation in terms of the separate enjoyment, committed physicist and problem-solving variables.

The multiple regression technique has shown that,of the four factors,enjoyment is the one most strongly associated with attainment in O-level physics. The overall correlation of G.C.E. achievement with physics enjoyment of 0.32 can be compared with a value of 0.55 obtained by Nuttall (1971) with the original form of the Science Attitude Questionnaire. Gardner (1975b) has suggested that Nuttall's value might be inflated by possible tautological assumptions. The evidence from the present survey with the modified questionnaire is that Gardner's criticism could well be justified.

The relatively strong association of enjoyment with achievement for girls appears to be a unique finding. Nuttall did not report any sex differences in his work with the Science Attitude Questionnaire.The Schools Council study (Eggleston et al., 1976) did not use the correlation technique to explore this relationship. The implication of the present research is that teachers of girls should strive to produce a classroom environment where enjoyment of physics can develop. Whatever teaching approach is adopted, an implicit aim should be that the girls are to enjoy the subject. Of course, as pointed out earlier (Elton, Section 2.3), a correlation coefficient is no real indication of 'cause and effect'. Yet, what has been obtained here is notification of an inter-relation between attainment and enjoyment. While it is likely that cognitive achievement in terms of homework and test marks causes pupils to internalise their success as a well-being towards the subject, subject enjoyment, arguably from any source, cognitive or social, can itself act as motivation to achieve. The enjoyment-attainment relationship is thus an integral part of a loop with the affective and cognitive components continually inter-acting one upon the other. The research reported here has inspected the enjoyment-attainment looop at two specific times, measuring first enjoyment and then, several months later, achievement. The 'status' of the loop has been reported. If teachers prepare their lessons to encourage subject enjoyment, their pupils can operate within the high attainment-high enjoyment loop: if enjoyment is not encouraged, the pupils are more likely to operate in a low attainment-low enjoyment looop. Enjoyment of physics is more important for girls, but it would be a most unusual teacher who, in either a mixed or in an all boys' class, would use the results of this research to neglect the development of boys' enjoyment, too!

7.3. MOTIVATION, STUDY METHODS AND PERSONALITY

7.3.1. FOUR PERSONALITY GROUPS

The mean scores on the study orientation and personality scales appear in table 7.3.1. Significant sex differences (at the 1% level)are found in both study methods and neuroticism scores; the girls are more neurotic - this finding is as expected (Eysenck and Eysenck, 1964) - and they have the better study methods.

Table 7.3.1 MEAN SCORES ON ALL THE SCALES

Scale	Mean Score (standard deviation)		
	Boys N = 525	Girls N = 201	All N = 726
Study methods (S)	4.67 (2.34)	5.20 (2.22)	4.82(2.32)
Academic motivation (MA)	5.38 (1.47)	5.34 (1.21)	5.37(1.45)
Self-confident motivation (MB)	4.61 (1.97)	4.39 (2.00)	4.55(1.98)
Motivation (M = MA + MB)	9.99 (2.90)	9.73 (2.84)	9.92(2.88)
Study orientation (MS=M + S)	14.66 (4.58)	14.94 (4.18)	14.74(4.47)
Extraversion	13.38 (4.13)	13.43 (4.72)	13.40(4.30)
Neuroticism	10.40 (4.09)	11.93 (4.19)	10.82(4.17)
Lie	2.76 (1.70)	2.79 (1.77)	2.77(1.72)

Taking respective mean scores on the extraversion and neuroticism scales as criteria, the students can be allocated to one of four personality groups. Table 7.3.2 gives the mean scores for these groups on all the scales.

The mean scores of the stable introverts on four of the five study orientation scales are significantly superior at the 1% level. However, no significant differences at all arise on the academic motivation scale MA. There appear to be no real differences in study orientation between unstable introverts and stable extraverts, but it is clear that stable introverts and unstable extraverts lie

TABLE 7.3.2. MEAN SCORES OF THE FOUR PERSONALITY GROUPS

Personality Groups	N	MEAN SCORE ON SCALE (STANDARD DEVIATION)							
		Extraversion	Neuroticism	Lie	S	MA	MB	M	MS
Stable Introverts	154	9.73 (2.90)	7.29 (2.18)	3.57 (1.82)	5.88 (1.90)	5.54 (1.40)	5.06 (1.91)	10.60 (2.88)	16.48 (4.02)
Unstable Introverts	198	9.87 (2.74)	14.31 (2.81)	2.90 (1.65)	4.48 (2.38)	5.47 (1.43)	4.30 (1.98)	9.77 (2.94)	14.61 (4.57)
Stable Extraverts	195	17.01 (2.27)	7.35 (2.26)	2.62 (1.54)	4.57 (2.40)	5.23 (1.45)	4.77 (1.99)	10.00 (2.80)	14.57 (4.54)
Unstable Extraverts	179	16.52 (2.15)	13.80 (2.48)	2.11 (2.59)	4.16 (2.17)	5.29 (2.49)	4.13 (1.91)	9.42 (2.83)	13.58 (4.24)

at opposite ends of the personality - study orientation continuum.

An intriguing trend appears in the lie scale means: stable introverts with high study methods and motivation scores have the significantly highest lie scores (at the 1% level). This could mean that superiority of the stable introverts is due, in part, to a tendency to fake their responses (Eysenck and Eysenck, 1964). A further discussion of this possibility appears later.

Table 7.3.1 shows that significant sex differences can occur. The influence of these on the results of table 7.3.2 is that the stable introvert grouping would be deficient in girls defined as stable by a slightly different sex dependent criterion (girls who score 11 on the neuroticism scale are classified 'unstable' according to the mean of 10.82 in table 7.3.1 for the whole sample, but they are classified as 'stable' according to the mean of 11.93 for the girls sub-sample). As girls tend to have better study methods scores, it follows that if the 'missing' stable girls are transferred from the unstable introvert to the stable introvert category of table 7.3.2, the only result will be an enhancement of the superiority of stable introverts on the study methods and MS dimensions.

7.3.2 THE INFLUENCE OF SEX ON THE STUDY ORIENTATION-PERSONALITY RELATIONSHIP

The intercorrelations of the variables of table 7.3.1 are shown in table 7.3.3 separately for boys and girls.

Table 7.3.3. INTERCORRELATIONS OF VARIABLES BY SEX

Variable	S	MA	MB	M	MS	Extraversion	Neuroticism	Lie
S		43**	45	52*	84*	-27	-23	27
MA	21**		41	79	72	-17	-05	04
MB	36	38		89	79	-11*	-22	19
M	36*	76	89		90	-16**	-18	15
MS	77*	63	79	87		-24	-23	23
Extraversion	-23	-04	07*	03**	-10		-09	-26
Neuroticism	-23	02	-24	-16	-23	-21		-14
Lie	29	12	09	13	24	-26	-21	

Decimal points are omitted
For boys, above the diagonal, N = 525, a correlation of 0.09 is significant at the 5% level.
For girls, below the diagonal, N = 201, a correlation of 0.14 is significant at the 5% level.
Sex differences are **p<1% and *p<5%

Relationships between pairs of variables that involve either neuroticism or lie dimensions are independent of the sex factor. For instance, neuroticism shows a small negative correlation with extraversion for both boys and girls - there is a slight tendency for stable students to be extraverted.

Differences between the sexes start to occur when relationships involving extraversion are explored. Whilst extraversion correlates negatively with study methods for both boys and girls, the correlation with motivation shows some significant differences. There appears to be no correlation between extraversion and motivation for girls, although there is a definite tendency for well motivated boys to be introverted. The strongest difference seems to lie in the responses to the self-confident motivation scale MB; boys who score highly on this scale are more likely to be introverted than are girls who score similarly.

Academic motivation MA is more strongly associated with good study methods for boys than it is for girls. This association is responsible for motivation-study methods correlations of 0.52 and 0.36 for boys and girls respectively. Summarising the interactions:

(i) stable students are more likely to have good study methods, a high self-confident motivation, and a high overall study orientation;

(ii) good study methods are associated with introversion, and

(iii) introversion in boys is associated with all-round motivation and hence a high study orientation.

7.3.3. THE SIGNIFICANCE OF THE LIE SCALE

Previous educational research with the Eysenck Personality Inventory is remarkable in so far as very little reference has been made to the Lie scores of respondents. In the Inventory Manual (Eysenck and Eysenck, 1964), it is pointed out that the Lie scale was shown to be a reliable and valid means of checking the genuineness of responses to the earlier Maudsley Personality Inventory. A 'cut-off' lie score of 4 or 5 is suggested although 'no absolute guidance can be given for its use' (op.cit. p.14).

Analysing the study orientation and personality variables by lie score (Appendix 7.3.1) shows trends consistent with faked responses associated with high lie scores; for example, the higher the lie score the 'better' the study methods. The relationships for the four major variables are shown graphically in figures 7.3.1. to 7.3.4.

The sizes of each lie sub-group are inevitably small and the error spread of the points (the standard error of the mean is shown) makes the drawing of firm conclusions hazardous. In the Manual, Eysenck suggests that it is the

Fig. 7.3.1 The variation of extraversion with lie score

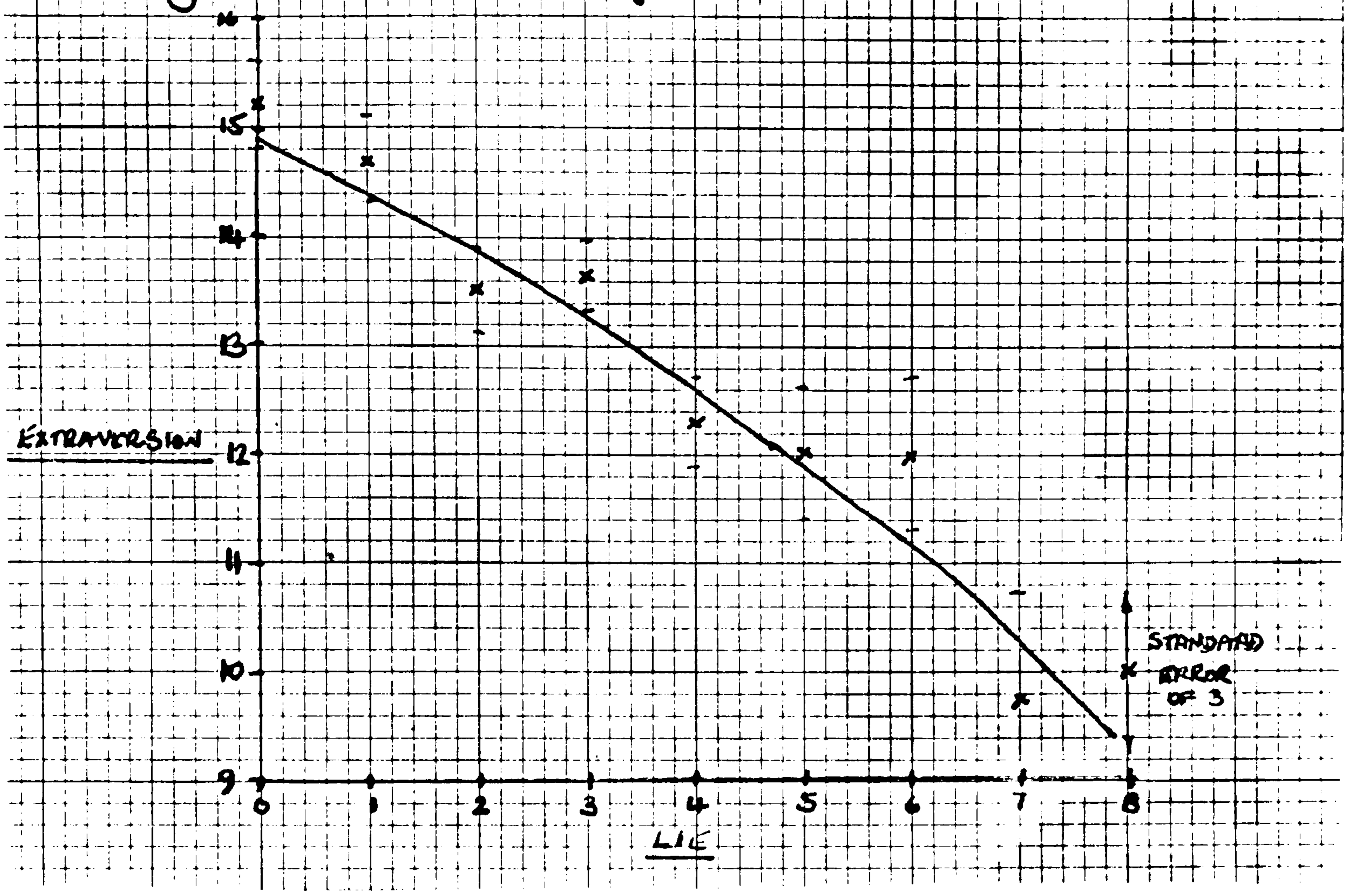
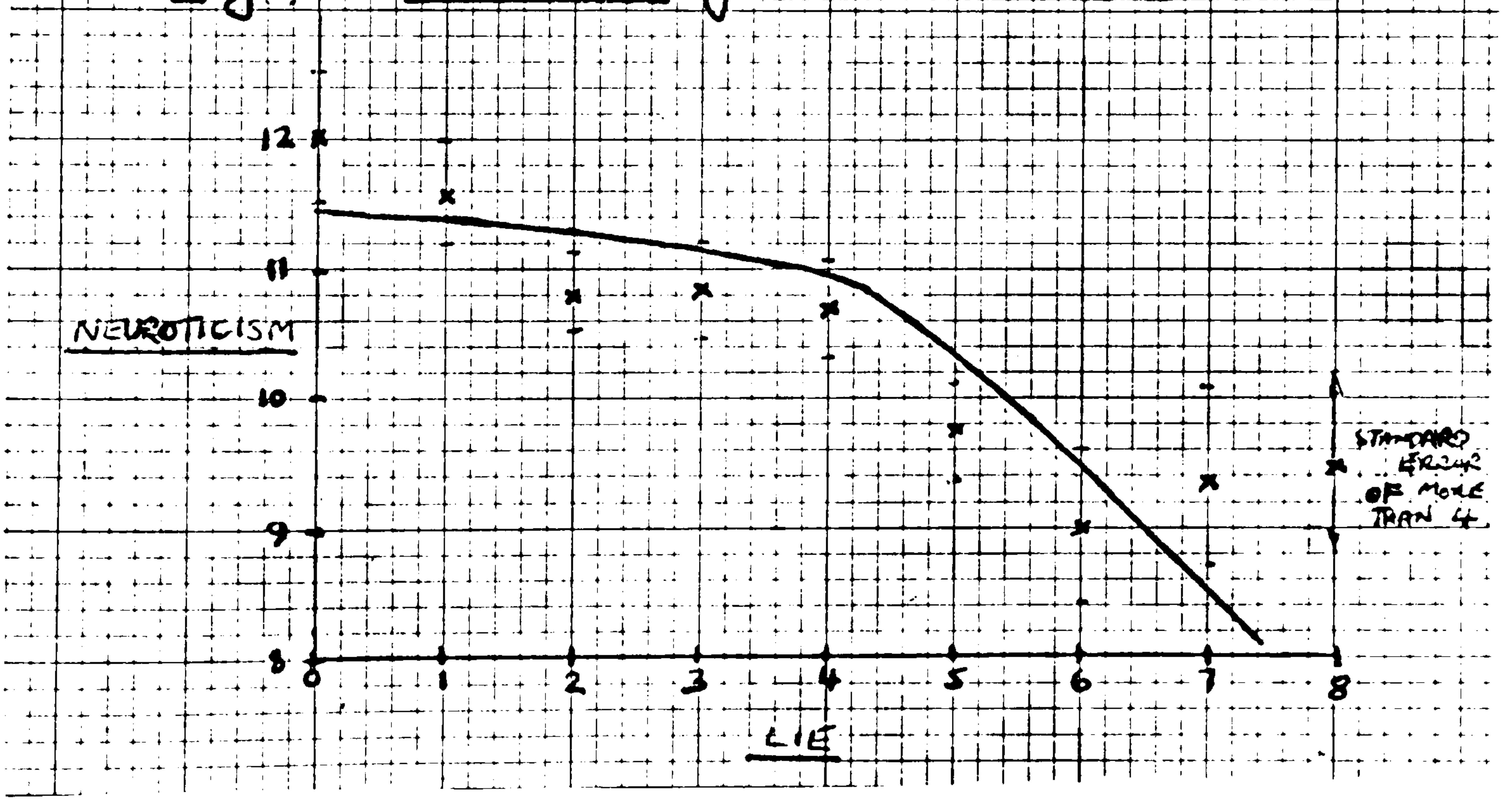


Fig. 7.3.2 The variation of neuroticism with lie score



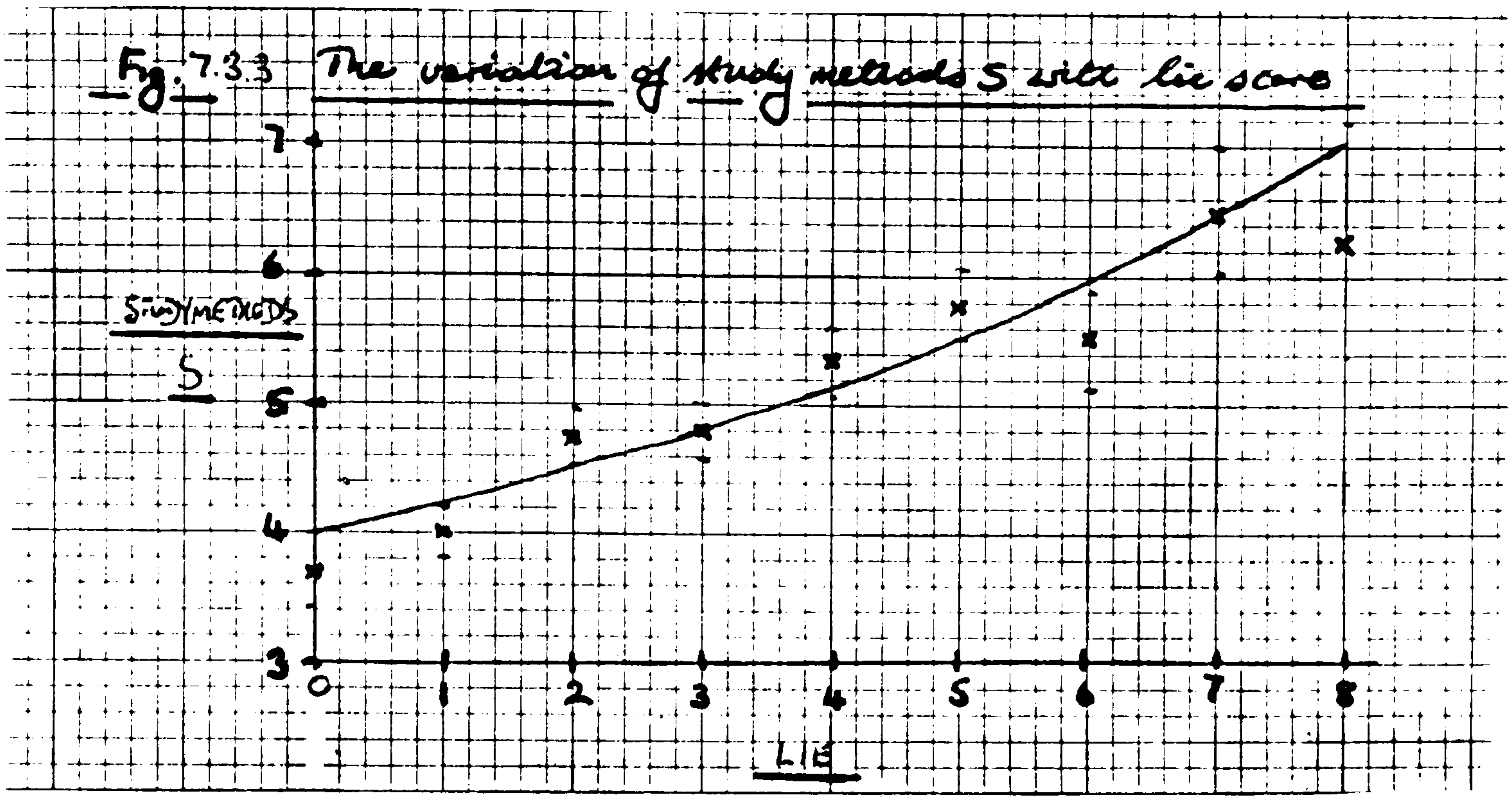


Fig. 7.3.3 The variation of study methods S with lie score
STUDY METHODS
S
3
4
5
6
7
0
1
2
3
4
5
6
7
8
LIE

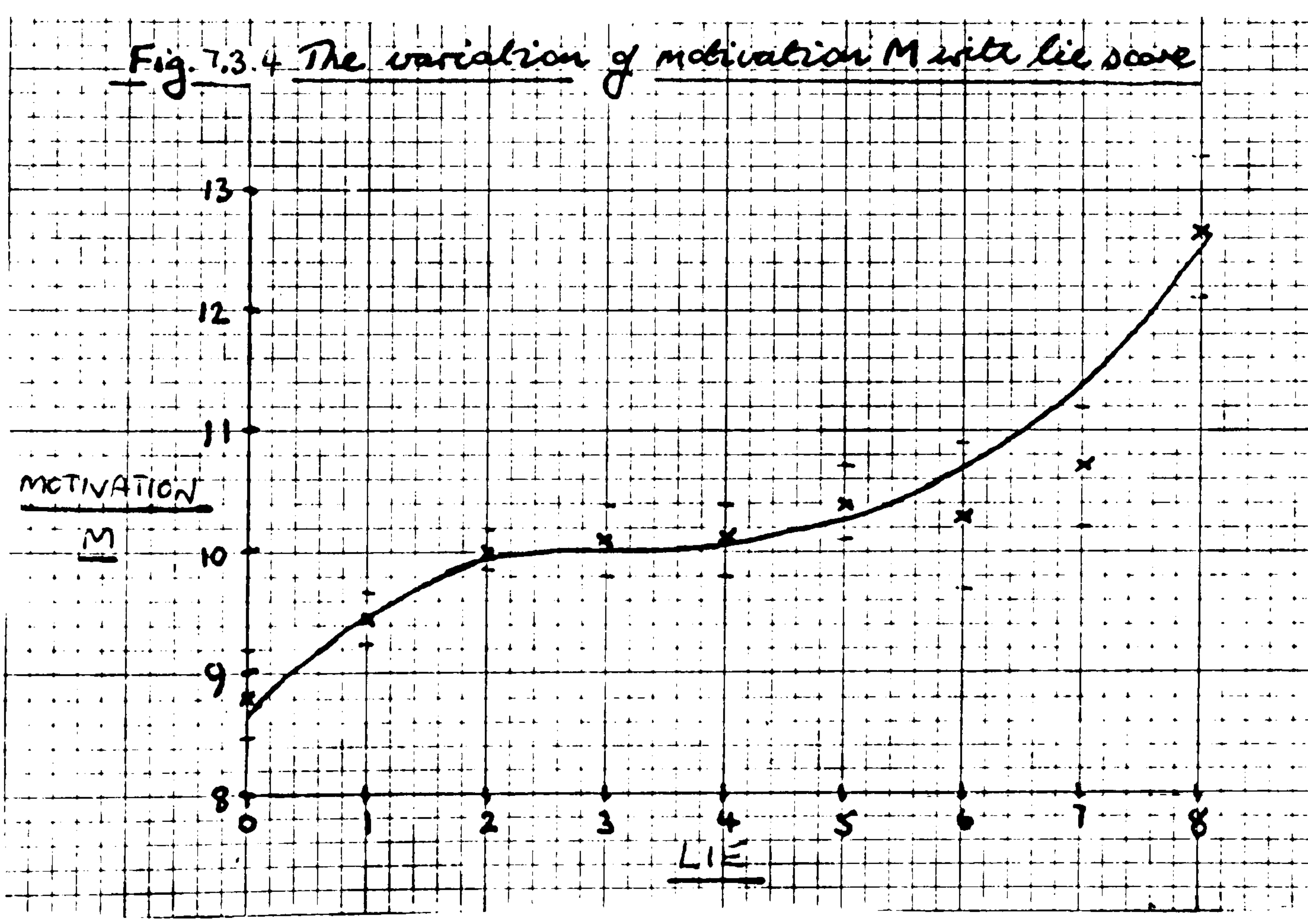


Fig. 7.3.4 The variation of motivation M with lie score
MOTIVATION
M
8
9
10
11
12
13
0
1
2
3
4
5
6
7
8
LIE

neuroticism trait that is most likely to be affected by high lie scores. Fig. 7.3.2. shows that neuroticism is largely independent of lie score until the latter is greater than 4, which is confirmed by a statistical t-test on the neuroticism mean scores for lie values of 1 and 4 : there is no significant difference. This is encouraging evidence for the Eysenck criterion of a lie score of 4 or less as an indicator of genuineness of response.

Applying the Eysenck cut-off criterion to the other three figures does not, at first sight, seem to be of much use: each variable shows a significant and consistent change with increase in lie score from zero. However, if it is assumed, not unreasonably, that the neuroticism dimension alone determines the cut-off criterion, the changes in extraversion, study methods and motivation below the cut-off value are real changes due to the association of another aspect of the lie factor, which is distinct from that of untruth in response, with introversion, good study methods and, to a lesser degree, good motivation.

The dual nature of the lie factor hypothesised, then, is as follows:

(i) a sub-dimension associated with a carefully organised and consistent system of personal and social relationships measured across the complete range of the lie scale scores; the extension of these personal qualities to academic learning causes positive correlations with study methods (strong) and motivation; generally this lie sub-dimension is a more typical attribute of introverts, and

(ii) a sub-dimension associated with untruthful responses, indicated by a lie scale score of 5 or more: originally, this was the only interpretation of the scale.

Respondents scoring 4 or less on the lie scale are readily accommodated on the 'organisation' sub-dimension (i). On the other hand, those scoring 5 or above are students who might be (a) very strong on the 'organisation' sub-dimension and low on untruthfulness, or (b) very low on 'organisation' but high on untruthfulness, or even some combination of (a) and (b). It is beyond the design of the present study to isolate sub-groups (a) and (b). So to remove the influence of untruthful category (b) students, the data was re-analysed to exclude all with lie scores of 5 or more.

Table 7.3.4. THE LIE SCORE CUT-OFF

Lie Score Range	N	Extraversion	Neuroticism	S	M	MS
4 and below	612	13.72(4.25)	11.07(4.16)	4.63(2.31)	9.82(2.94)	14.45(4.53)
5 and above	114	11.65(4.15)	9.51(4.01)	5.82(2.08)	10.47(2.51)	16.28(3.85)
Significance level	-	1%	1%	1%	5%	1%

Table 7.3.4 shows that the sample excluded has significantly different characteristics from that remaining in the analysis. Nevertheless, when the reduced sample of 612 students is allocated amongst the four personality sub-groups of table 7.3.5, the overall pattern is still remarkably similar.

Stable introverts and unstable extraverts still occupy their significantly different positions at opposite ends of the study orientation continuum. This time the superiority of the stable introverts on the academic motivation scale MA reaches significance too, at the

TABLE 7.3.5. MEAN SCORES OF THE FOUR PERSONALITY GROUPS WITH LIE SCORES OF 4 and LESS

Personality Groups	MEAN SCORE ON SCALE (STANDARD DEVIATION)								
	N	Extraversion	Neuroticism	Lie	S	MA	MB	M	MS
Stable introverts	134	9.99 (2.89)	8.05 (2.37)	2.53 (1.17)	5.66 (2.00)	5.63 (1.35)	4.96 (1.97)	10.58 (2.92)	16.24 (4.08)
Unstable Introverts	141	9.81 (2.70)	15.14 (2.52)	2.44 (1.50)	4.53 (2.35)	5.32 (1.53)	4.12 (2.08)	9.44 (3.10)	13.97 (4.81)
Stable extraverts	207	16.98 (2.22)	9.04 (2.43)	2.22 (1.21)	4.45 (2.43)	5.28 (1.44)	4.81 (1.98)	10.09 (2.79)	14.54 (4.47)
Unstable extraverts	130	16.61 (2.19)	14.60 (2.24)	1.75 (1.28)	3.98 (2.04)	5.21 (1.51)	3.81 (1.80)	9.02 (2.78)	13.00 (4.12)

5% level, and the differences on all the other scales are significant at the 1% level as before.

There is only one difference in the behaviour of the median groupings of unstable introverts and stable extraverts, the latter score significantly higher at the 1% level on the confident motivation scale MB.

The stability of th relationships is further demonstrated when the sex analysis of table 7.3.3 is repeated.

Table 7.3.6. INTERCORRELATION OF VARIABLES BY SEX FOR STUDENTS WITH LIE SCORES OF 4 AND LESS

Variable	S	MA	MB	M	MS	Extraversion	Neuroticism	Lie
S		43**	47	53**	84*	-26	-22	22
MA	18**		44	79	72*	-13	-04	06
MB	36	35		89	81	-10	-22	18
M	34**	75	88		91*	-13	-17	15
MS	76*	61*	80	87*		-22	-22	21
Extraversion	-17	-07	09*	03	-07		-14	-21
Neuroticism	-17	06	-21	-12	-17	-24		-07
Lie	22	10	01	06	16	-16	-17	

Decimal points omitted
For boys, above the diagonal, N = 442, a correlation of 0.09 is significant at the 5% level
For girls, below the diagonal, N = 170, a correlation of 0.15 is significant at the 5% level.
Sex differences are **p<1% and *p<5%

Although it is true that some of the earlier differences have been sharpened or blurred slightly, a change in significance level in the difference in association between study methods and motivation for instance, the three general conclusions on the interactions of all the variables are still valid. Table 7.3.7 summarises this final analysis.

Table 7.3.7 BOYS AND GIRLS DIFFERENCES AFTER EXCLUDING HIGH LIE SCORES

	Boys	Girls
Neuroticism	Stable boys have good study methods and a high (self-confident) motivation	Stable girls have good study methods and a high (self-confident) motivation
Extraversion	Introverted boys have good study methods and a high motivation	Introverted girls have good study methods
Lie as 'organisation'	High scoring boys have good study methods, high motivation and are introverted	High scoring girls have good study methods and have a slight tendency to be introverted and stable
Study orientation variables	Well motivated boys have good study methods	Well motivated girls have good study methods

7.3.4. STUDY ORIENTATION, PERSONALITY AND ATTAINMENT

Grades awarded in the O-level physics examination were scored on a six-point scale (Section 5.1.2) and correlated separately for boys and girls with the two major study orientation variables and the personality variables.

TABLE 7.3.8. CORRELATES WITH ATTAINMENT

Variable	Correlation with attainment G.C.E. boys (N = 382)	G.C.E. girls (N = 151)
Study methods (S)	0.20**	0.12
Motivation (M)	0.39**	0.28**
Extraversion	-0.21**	-0.24**
Neuroticism	-0.13*	0.04
Lie	0.05	0.12

** p < 1%; * p < 5%

As table 7.3.8 shows attainment correlates most strongly with motivation and introversion. The significance of the personality association is not surprising on the evidence of Section 2.5. The strong dependence of attainment on motivation contrasts with the inability of many earlier studies to reveal significant results (for example, Hartley et al., 1971, and Weiner, 1972).

Additional significant attainment associations for the boys only are with good study habits and with a stable personality. The sex dependent attainment/neuroticism relationship is consistent with earlier findings from higher education (Entwistle and Wilson, 1977).

7.3.5 CONCLUDING REMARKS

In Chapter 2, a call was made for hard evidence from the secondary education sector, that definite relationships between personality and study orientation variables did exist, before endorsing the suggestion that systematic instruction in study strategy should be a more important aim in the secondary area than perhaps it is at present. The research results reported here confirm that Entwistle's higher education findings and attitude scales (Entwistle et al., 1971b) generally have a relevance and application in the schools. The scales, in a modified form, comprise a valid and reliable measure of study methods and motivation in the school environment. In close agreement with Entwistle's results, stable students have been found to have the highest study methods and motivation scores. Results peculiar to the school sample are that introversion is also associated with good study habits for both boys and girls, and in the case of the former, introverts tend to have high motivation. There seems to be no relationship between extraversion and motivation for the schoolgirls of this sample.

The need for teachers to instruct extraverted and unstable students in good study methods is thus demonstrated. Whilst the personality characteristics of stable and introverted students leads them naturally to plan ahead and organise their study methods objectively, with anxious and sociable students such an objectivity is harder to achieve. Unstable students are likely to worry to an even greater degree than usual if they are unsure of the correct study strategy to be adopted. Extraverted students are likely to find that their natural ebullience inhibits a more methodical approach to studying, unless they are conscious of an 'approved' study system, in which case they would be called upon to suppress their extraversion for the sake of improved study methods - such a course of action is most likely if the student is well motivated towards academic studies, which leads in turn to the hypothesis that well motivated extraverts should have good study methods. (Appendix 7.3.2.)

Evidence on the duality of the Eysenck Lie scale has been recently documented (Eysenck and Eysenck, 1976). The 'organisation' dimension of the scale identified in this research has been termed 'a measure of conformity to accepted social mores' by Eysenck, who has suggested that this may be another distinct personality factor. At present, there is no certainty in the interpretation of the Lie scale. Nevertheless, it has now been demonstrated that lie scores of more than 4 can still be taken as a measure of untruthfulness of response, although this procedure does inevitably cause a small proportion of valid responses to be rejected also. The application of a lie cut-off criterion, however, has only a minor influence on study orientation-personality interactions.

The worth of the study orientation scale to the classroom teacher is that of a rough screening device when the teacher first comes into contact with a class. Pupils scoring low on the scale can be immediately identified as potential under-achievers well before the teacher would otherwise be able to assess the pupils reliably from personal experience. Remedial action could then be taken by means of individual pupil interview and instruction. Under classroom conditions, it might be supposed that the data collected would be of doubtful validity as the pupils are presented with a novel form of test which is not anonymously completed and the responses to which might be supposed to result in 'painful' remedy if not 'correct'. To minimise this possibility, the Eysenck Lie scale could be added, and mixed with the study orientation items and perhaps some 'dummy' items to disguise the purpose of the test. Although the Lie scale is at present part of a 'restricted' test, it might be reconsidered whether such a state of affairs is ideal. The release of the Lie scale items for general use by qualified teachers, perhaps under the supervision of headteachers or LEA advisory staff, arguably, can only help the classroom teacher in improving the quality of the learning environment.

7.4. THE FIFTH-FORM PHYSICS CLASSROOM ENVIRONMENT

7.4.1. VARIED/TEACHING-FOR-UNDERSTANDING : A MIS-MATCH

Scores on the varied/teaching-for-understanding preference scale (Section 5.4.5) were compared with degree-of-use scores on the corresponding items (table 5.4.1). The match of pupil preference with reality is shown in table 7.4.1. , where the weaker preference scales also appear to allow tentative inferences to be drawn.

TABLE 7.4.1. MEAN SCORES ON THE FACTOR SCALES

Scale	Mean score per item (N = 741)	Mean standard deviation per item
Varied/teaching-for-understanding (preference)	2.55	0.30
Varied/teaching-for-understanding (reality)	2.20	0.38
Teacher-centred/notemaking (preference)	2.18	0.36
Teacher-centred/notemaking (reality)	2.50	0.26
Pupil-centred/textbook (preference)	1.76	0.37
Pupil-centred/textbook (reality)	1.53	0.35

$p < 1\%$ for all differences between preference and reality means (correlated t-test)

The clear preference for the varied/teaching-for-understanding style (significantly stronger for the girls - Appendix 7.4.1) is not accompanied by a matching provision in the classroom. The findings here are consistent with earlier research (Section 2.6): pupils are capable of expressing a need for a sound psychologically meaningful classroom environment, and, in doing so, are likely to report that their actual classroom experiences do not satisfy this need.

Comparison with the other two scales shows that, overall, the pupil-centred/textbook style is rated a poor method, while the most used classroom style is the teacher-centred/notemaking method. Thus it appears that the classes contributing to the present survey are most likely to be exposed to the'traditional' teaching method, and in this respect differ from the 'Nuffield'sample used in the Schools Council study (Eggleston et al., 1976) where the problem-solving style (varied/teaching-for-understanding) was predominant in physics classrooms.

7.4.2. MATCH AND MIS-MATCH FOR THE INDIVIDUAL PUPIL

A 'match' between a preference or intrinsic worth rating on the check-list (table 5.4.1 , scale A), and a degree of use rating (scale B) was defined as occurring when a pupil, in responding to a certain item, scored either '1' or '3' on both scales. Over the range of nineteen statements, this enabled a pupil to obtain a 'match'score of between 19, a perfect match, and zero. The match score was then correlated, in turn, with attainment, enjoyment and classroom environment variables for all pupils. Table 7.4.2 shows the inter-correlations broken down by sex and by type of examination course.

For all the sub-groups, high match scores are associated with the degree of varied/teaching-for-understanding actually experienced in the classroom (a scale B score). In other words, if the teaching style matches the pupil's preference, the predominant style is most likely to be the varied/teaching-for-understanding method, and most of the pupils will be enjoying the subject too.

TABLE 7.4.2. CORRELATIONS OF THE 'MATCH' SCORE

Sub-group		Correlation of match score with: physics attainment (G.C.E. or C.S.E.grade)	physics enjoyment	Degree of varied/teaching-for-understanding experienced
G.C.E. boys	(N = 366)	0.04	0.29**	0.43**
G.C.E. girls	(N = 151)	0.17*	0.21**	0.68**
C.S.E. boys	(N = 113)	0.14	0.25**	0.53**
C.S.E. girls	(N = 26)	-0.33	-0.36	0.68**

** $P < 1\%$; * $p < 5\%$

Attainment is less strongly related. Only for G.C.E. girls is the association of attainment and classroom match significant. Earlier, in Section 7.2.2 , it has been shown that a strong enjoyment-attainment loop exists for G.C.E. girls. It is now possible to add a 'treatment' component to this loop: a classroom environment that satisfies the girls' needs with an emphasis on the experience of the varied/teaching-for-understanding style.

The enjoyment-attainment loop for G.C.E. boys was shown in Section 7.2.2 to be weaker than for girls and this is illustrated by the coefficients in table 7.4.2. Classroom match is associated with enjoyment for the boys but 'match' shows no relationship with attainment.

7.4.3. CLASSROOM ENVIRONMENT CORRELATES WITH ATTAINMENT AND ENJOYMENT

By using the nine check-list items that are not contained within the 10-item varied/teaching-for-understanding scale, the relationships between the classroom environment variables and subject outcomes (attainment and enjoyment) might be further refined. Multiple regression analysis (Section 2.9) was used with G.C.E. or C.S.E. grade in physics as the attainment criterion and physics enjoyment, as measured in Section 5.2 , as the attitude criterion. The independent variables were the preference items (scale A, table 5.4.1) and the 10-item composite scale. The analysis was then repeated with the degree-of-use items (scale B, table 5.4.1) and the corresponding form of the composite scale.

Tables 7.4.3 to 7.4.6 show the items which make significant contributions (at the 5% level) to the regression equations. They are, then, those variables which have the strongest affect on the criterion.

TABLE 7.4.3. CORRELATES WITH ATTAINMENT - PREFERENCE ITEMS

Sub-group		Item	Beta Weight	Multiple Correlation
G.C.E. boys (N = 366)	3.	The teacher discusses each new with us, then we investigate this by ourselves and draw our own conclusions without further assistance	0.11	0.16
	9.	We work through a text-book	-0.11	
G.C.E. girls (N = 151)		Varied/teaching-for-understanding	0.24	0.36
	13.	We make our own notes from textbooks or worksheets	-0.23	
	12.	Duplicated notes are issued at the end of each lesson	-0.19	
C.S.E. boys (N = 113)		Varied/teaching-for-understanding	0.17	0.22
	14.	Groups of pupils make notes on different topics and these notes are circulated around the class	-0.14	
C.S.E. girls (N = 26)	19.	We work individually through worksheets	0.42	0.65
	7.	The teaching seems to be most suitable for the most able	-0.37	

TABLE 7.4.4. CORRELATES WITH ATTAINMENT - DEGREE OF USE ITEMS

Sub-group		Item	Beta weight	Multiple correlation
G.C.E.boys (N = 366)	19.	We work individually through worksheets	-0.14	
	12.	Duplicated notes are issued at the end of each lesson	-0.11	0.22
	9.	We work through a textbook.	-0.10	
G.C.E. girls (N = 151)	19.	We work individually through worksheets.	-0.21	
	13.	We make our own notes from text books or worksheets.	-0.18	0.36
		Varied/teaching-for-understanding.	0.16	
C.S.E. boys (N = 113)	12.	Duplicated notes are issued at the end of each lesson.	-0.25	0.37
	15.	Notes are made from dictation by the teacher.	-0.23	
C.S.E. girls (N = 26)		Varied/teaching-for-understanding.	-0.44	-0.44

TABLE 7.4.5. CORRELATES WITH ENJOYMENT - PREFERENCE ITEMS

Sub-group		Item	Beta weight	Multiple correlation
G.C.E. boys (N = 366)		Varied/teaching-for-understanding	0.15	
	7.	The teaching seems to be most suitable for the most able pupils	0.14	0.26
	16.	Notes are made by copying from the board or overhead projector	0.12	
G.C.E. girls (N = 151)		Varied/teaching-for-understanding	0.19	0.24
	12.	Duplicated notes are issued at the end of each lesson	-0.17	
C.S.E. boys (N = 113)		Varied/teaching-for-understanding	0.42	0.51
	7.	The teaching seems to be most suitable for the most able pupils	0.26	
C.S.E. girls (N = 26)		No one statement makes a significant contribution		

TABLE 7.4.6 CORRELATES WITH ENJOYMENT - DEGREE OF USE ITEMS

Sub-group	Item	Beta weight	Multiple correlation
G.C.E. boys (N = 366)	Varied/teaching-for-understanding	0.24	0.30
	7. The teaching seems to be most suitable for the most able	-0.12	
	9. We work through a textbook	-0.11	
G.C.E. girls (N = 151)	Varied/teaching-for-understanding	0.38	0.38
C.S.E. boys (N = 113)	Varied/teaching-for-understanding	0.37	0.44
	13. We make our own notes from text-books or worksheets	-0.19	
C.S.E. girls (N = 26)	14. Groups of pupils make notes on different topics and these are circulated around the class	0.44	0.44

The multiple correlation coefficient reported is between the scores on the criterion variable and the scores resulting from a regression equation comprising just the items indicated.

The major conclusion is that varied/teaching-for-understanding, both as a pupil preference and as a received mode of instruction, is strongly associated with subject enjoyment. The relationship is strongest for C.S.E. boys and G.C.E. girls: is weaker for G.C.E. boys, but is insignificant for C.S.E. girls.

Varied/teaching-for-understanding is associated with attainment for G.C.E. girls but not for the G.C.E. boys. In fact, the classroom environment variables are able to account for only a few percent of the variance of the attainment scores for G.C.E. boys. Those few checklist items that do have a significant association with the boys' attainment scores appear to reflect chance relationships in the sample of the survey rather than point to possible predictive associations which might be expected to lead to high attainment. For instance, in table 7.4.4, high achieving G.C.E. boys are unlikely to be using worksheets in their classes. It would be naive to assume that prohibiting the use of worksheets would lead to an improvement in attainment. Indeed, the findings here for the G.C.E. boys confirm those in Section 7.4.2, where classroom 'match' was investigated ; while manipulating the classroom environment might have an effect on attainment for girls, it is unlikely to do so for the boys.

Despite the limitations of the multiple regression technique (Section 2.9), the analysis has shown that perceived and preferred teaching styles and classroom organisation are associated with attainment and enjoyment outcomes. Sex and the intellectual level of the pupil have characteristic influences on these outcomes.

7.4.4. CONCLUDING REMARKS

The check-list responses (table 5.4.1. and figure 5.4.1.) show that a significant mis-match occurs in the physics classrooms of this survey. The profile of a preferred teaching methodology that has been obtained with its emphasis on the planned learning of related concepts in a teacher directed environment, has much in common with Gagné's learning theory (Section 2.6). This could be said to establish the validity of the preference responses. As the preference profile identified is very similar to that found when essentially the same check-list was used previously with a different sample of schools (Pell, 1977), the stability of the profile is demonstrated. The profile does not simply reflect the sample of schools in the survey.

The mis-match illustrated by responses to the varied, multi-media, check-list item 4 is of particular significance. The pupils' preferences support the evidence from the Harvard Project Physics evaluators and other researchers (Section 2.6.), that the multi-media and multi-style approach is conducive to optimum learning. Yet, the classroom experience is deficient in this area for most pupils.

Implications for teacher-centred curriculum development are exemplified by the comparison of check-list responses for classes X and Y in Section 5.4.3. It would be a rewarding experience for the classroom teacher if he could perform a self-evaluation from time to time by comparing his pupils' perceptions of his teaching style with the 'population' preference profile of table 5.4.1.

The purpose of the check-list initially was to identify a preferred learning profile. In the event, three dimensions to this profile have been revealed. That two of these dimensions proved difficult to measure reliably is incidental to their positive identification. If further research is to be pursued in an attempt to increase scale reliability, additional items need to be added and the response categories increased from three to five, say, to improve the precision of the ratings.

The three valid scales of pupil preferred teaching style have been compared in Section 5.4.5. with the three cognitive scales of teacher behaviour established with the Science Teaching Observation Schedule. There appears to be substantial correspondence for two of the scales, but the third shows differences, probably characteristic of the two samples of schools. The opportunity sample of the present survey attracted predominantly 'traditionally' taught classes, according to the evidence of Section 7.4.1. Pupil-centred activities in these classes tend to be textbook oriented. In the Schools Council survey of 'Nuffield' schools, the pupil-centred activities were more likely to be open-ended investigations consistent with the nature of science. If this explanation is accepted, it is possible to equate all three scales of the two surveys, which brings comfortably together the findings of the quantitative observation schedule and pupils' attitudinal perceptions.

However, as the original form of the observation schedule does not permit information on the nature of the medium of instruction to be recorded (the modified form of the schedule in Appendix 5.4.3A does allow this but, at the moment, is relatively untested), the correspondence of the three teaching styles, though welcome, might be slightly fortuitous. It would be worthwhile to run both the checklist (with extra items to strengthen the weaker scales) and the modified observation schedule together to obtain inter-validity measures.

With the psychologically sound varied/teaching-for-understanding style showing relatively strong association with physics enjoyment, and, in the case of G.C.E. girls, some association with attainment, it is desirable that physics teachers should endeavour to satisfy their pupils' needs in this respect by creating conditions for learning in their classrooms that follow the profile of table 5.4.6.

The match between pupil preference and perceived teaching method shows moderate association with physics enjoyment. This is a confirmation of the findings of Crawley and Shrum for university physics students. A unique contribution from the present research is that the degree of match depends upon the teaching style - the match is greatest when the varied/teaching-for-understanding style is employed. There is also the first evidence available that attainment is related to the degree of match, although only for able girls.

No analysis has been reported in terms of a possible pupil stereotype grouping. If such a grouping exists, it could well be that 'match' relationships with attainment, attitudes and the varied/teaching-for-understanding style can be identified with more precision. This approach, using the technique of cluster anlaysis with additional variables included, appears in Section 7.11.

7.5. COMPARATIVE SUBJECT ATTITUDES

7.5.1. SUBJECT RANK ORDERS

Subjects were ranked according to their z-score from the Kolmogorov-Smirnov (KS) goodness-of-fit test (Section 5.5.2.). The rank-orders appear in tables 7.5.1. to 7.5.6.

TABLE 7.5.1. RANK ORDERS FOR 'INTEREST'

INTERESTING (B)			
Boys		Girls	
Subject	z-score	Subject	z-score
Mathematics	14.67	Biology	9.75
Physics	14.62	Mathematics	8.72
Chemistry	13.06	Chemistry	8.02
Biology	2.16	English language	7.88
Geography	11.80	Geography	7.05
English language	9.01	English literature	7.01
History	9.01	French	6.61
English literature	8.00	Physics	6.37
French	-9.27	History	5.46
DULL (A)			

TABLE 7.5.2. RANK ORDERS FOR 'SYLLABUS CONTENT'

CONTAINS TOO MUCH MATERIAL (B)			
Boys		Girls	
Subject	z-score	Subject	z-score
Chemistry	-9.11	Physics	6.21
Biology	-9.19	History	4.00
French	-9.51	Geography	-4.67
History	-7.39	Chemistry	-6.22
Geography	-9.95	English literature	-7.09
English literature	-10.29	Biology	-7.24
Physics	-12.03	French	-8.00
Mathematics	-14.89	Mathematics	-9.86
English language	-16.25	English language	-10.55
CONTAINS SUFFICIENT MATERIAL (A)			

7.5.3. RANK ORDERS FOR 'DIFFICULTY'

DIFFICULT (B)			
Boys		**Girls**	
Subject	z-score	Subject	z-score
Physics	13.17	Physics	8.82
Chemistry	10.13	Chemistry	5.32
French	9.51	French	4.57
English literature	7.09	Geography	-4.25
Biology	-6.58	History	-4.37
History	-7.18	Mathematics	-4.82
Mathematics	-8.61	English literature	-5.11
Geography	-9.25	Biology	-6.17
English language	-12.76	English language	-7.80
EASY (A)			

TABLE 7.5.4. RANK ORDERS FOR 'BORING'

BORING (B)			
Boys		**Girls**	
Subject	z-score	Subject	z-score
French	9.69	Physics	4.68
English literature	9.26	French	4.32
English language	7.32	English literature	4.12
History	-5.91	English language	3.98
Geography	-6.53	History	-3.76
Biology	-7.35	Geography	-4.15
Mathematics	-7.97	Mathematics	-4.74
Physics	-8.31	Chemistry	-5.41
Chemistry	-8.74	Biology	-6.71
EXCITING(A)			

TABLE 7.5.5. RANK ORDERS FOR 'MODERN'

MODERN (B)			
Boys		Girls	
Subject	z-score	Subject	z-score
Mathematics	16.67	Mathematics	9.56
Physics	16.03	Biology	8.94
Chemistry	13.75	Chemistry	7.84
Geography	12.08	French	7.76
English language	12.00	Englsh language	7.26
Biology	11.31	Physics	6.98
French	9.69	Geography	6.53
(History)	(5.62)	English literature	4.37
English literature	-8.77	(History)	(2.91)
OUT OF DATE (A)			

TABLE 7.5.6. RANK ORDERS FOR 'PRESTIGE'

LOW PRESTIGE (B)			
Boys		Girls	
Subject	z-score	Subject	z-score
French	6.02	History	-3.27
History	5.00	Geography	-3.62
Geography	-6.64	English literature	-4.95
English literature	-7.58	English language	-5.95
Biology	-7.92	Biology	-5.99
Chemistry	-11.35	French	-6.37
English language	-12.14	Chemistry	-6.67
Physics	-14.44	Physics	-7.90
Mathematics	-15.53	Mathematics	-8.41
HIGH PRESTIGE (A)			

In the tables, positive z-scores indicate that the attitudinal rating is directed towards construct pole B, whereas negative z-scores imply a rating towards pole A.

Comparing the subject rank-orders for boys and girls on each construct in turn (table 7.5.7) shows that there is some measure of agreement between the sexes when subjects on the difficulty and prestige scales are rated. However, on the other four scales, the overall subject orders show a sex dependence.

TABLE 7.5.7. RANK ORDER CORRELATIONS

Construct scale	Rank-order correlation for boys and girls
Interesting	0.48
Too much material	0.28
Difficult	0.70
Boring	0.46
Modern	0.40
Low prestige	0.65

The correlation co-efficients in the table are significantly different from zero at the 5% level only where they exceed 0.60 (Siegel, p.284)

On the 'modern' scale, ratings of history were omitted from the calculation of the correlation between the boys' and girls' responses. This was because of the ambiguity in judging history according to this criterion, although the relevant segment of the grid had been retained to ensure a uniform design.

For both boys and girls, physics, chemistry and French are the most difficult subjects with English language the easiest. Also, physics and mathematics are seen by both boys and girls as being of high prestige while history and geography (and for boys, French) are given low ratings.

On the other four scales notable differences between the sexes are

(a) the relatively poor image of physics held by the girls, who rate the subject boring, relatively dull and overloaded in content;

(b) the relatively poor image of French held by the boys, who rate it boring and dull, and

(c) the attractiveness of biology to the girls, who rate it exciting and interesting.

7.5.2. CORRELATIONS BETWEEN THE RANK ORDERS

The subject rank-orders for the construct scales can be correlated to give a matrix of rank-order correlation coefficients (table 7.5.8). This is equivalent to the factor analysis reported in Section 5.5.3.

TABLE 7.5.8. CORRELATIONS BETWEEN THE CONSTRUCTS

	Interest	Too much material	Difficult	Boring	Modern	Low prestige
Interest		-44	08	-92**	91**	-83**
Too much material	-58		47	-15	-32	53
Difficult	-45	65*		-30	07	01
Boring	-78*	30	30		-81*	65*
Modern	71*	-48	-07	-62		-76*
Low prestige	-37	23	-35	02	-67*	

** p < 1%; p < 5%

Decimal points are omitted.
Boys rankings appear above the diagonal: girls below.
History was omitted when rank-orders were compared on the 'modern' scale.

The matrix confirms the existence of the 'satisfaction' factor for both the boys and the girls, although it appears to be a stronger attribute of the boys. The 'slog' factor also emerges but much more strongly in the case of the girls.

7.5.3. THE CHARACTERISTICS OF THE A-LEVEL PHYSICS CHOOSERS

After filling in the grid, the pupils were asked whether they intended to study subjects at A-level and if so, which subjects these would be (Section 5.6). Those choosing A-level physics defined a sub-sample whose subject ratings were re-analysed.

Tables 7.5.9 and 7.5.10 show the rank-orders on two of the construct scales. The remaining scale responses are summarised in Appendix 7.5.1.

TABLE 7.5.9. RANK ORDERS FOR 'INTEREST' (PHYSICS CHOOSERS)

INTERESTING (B)			
Boys		Girls	
Subject	z-score	Subject	z-score
Physics	13.02	Chemistry	5.25
Mathematics	11.08	Physics	5.22
Chemistry	11.06	Biology	5.10
Biology	9.46	Mathematics	5.07
Geography	7.62	English literature	3.90
English language	6.61	French	3.51
History	4.82	Geography	3.46
English literature	-6.44	English language	3.13
French	-7.11	History	2.31
DULL (A)			

TABLE 7.5.10. RANK ORDERS FOR 'DIFFICULTY' (PHYSICS CHOOSERS)

DIFFICULT (A)			
Boys		Girls	
Subject	z-score	Subject	z-score
French	7.02	Physics	3.28
Physics	6.27	Chemistry	3.09
English literature	6.05	French	2.44
Chemistry	6.03	History	1.44
History	-3.62	Geography	-2.12
Biology	-5.62	English literature	-2.34
Geography	-6.41	Biology	-3.45
Mathematics	-7.30	English language	-3.73
English language	-7.95	Mathematics	-3.88
EASY (B)			

The most striking findings are:

a) both boys and girls rate physics as difficult, even though they are choosing the subject at A-level - for girls, it is the most difficult subject and, for boys, it is second only to French in difficulty (table 7.5.10);

b) girl physics choosers rate mathematics as the easiest subject (table 7.5.10);

c) physics is rated the most interesting subject by the boy choosers, and even the girl choosers rate it very highly, finding it more interesting than biology (table 7.5.9);

d) girl physics choosers rate the O-level course as less overloaded in content than does the general population (table A, Appendix 7.5.1), and

e) both boys and girls choosing the A-level subject rate the course at O-level as more exciting than do the general population (table B, Appendix 7.5.1.).

Amongst the physics choosers, there is now more consistent agreement between boys and girls on the relative rankings of the subjects as table 7.5.11 indicates.

TABLE 7.5.11. RANK ORDER CORRELATIONS BETWEEN BOYS AND GIRLS RATINGS

Scale	Correlation for ALL boys and girls	Correlation for physics choosing boys and girls
Interesting	0.48	0.67*
Too much material	0.28	0.68*
Difficult	0.70*	0.78*
Boring	0.46	0.70*
Modern	0.40	0.74*
Low prestige	0.65*	0.67*

* $p < 5\%$

Physics choosing girls apparently judge the relative merits of their subjects in the same way as do the physics choosing boys.

7.5.4. DIFFERENCES IN COMPOSITE PHYSICS ATTITUDE SCORES

Summated attitude scores for 'satisfaction' and 'slog' were calculated as explained in Section 5.5.3. Mean scores for various sub-groups are compared in table 7.5.12.

TABLE 7.5.12. 'SATISFACTION' AND 'SLOG' DIFFERENCES

		Mean Score (standard deviation)	
Sample	N	'satisfaction'	'slog'
All boys	485	9.71 (2.12)	4.27 (1.38)
All girls	170	8.95 (2.13)**	4.71 (1.21)**
Boys choosing physics	220	10.73 (1.42)	3.74 (1.33)
Girls choosing physics	45	9.87 (1.82)**	4.29 (1.27)*
Boys rejecting physics	122	8.43 (2.19)	4.93 (1.20)
Girls rejecting physics	104	8.60 (2.19)	4.95 (1.14)
All physics choosers	265	10.58 (1.52)	3.83 (1.34)
All physics rejectors	226	8.51 (2.19)**	4.94 (1.17)**
Boys choosing physics	220	10.73 (1.42)	3.74 (1.33)
Boys rejecting physics	122	8.43 (2.19)**	4.93 (1.20)**
Girls choosing physics	45	9.87 (1.82)	4.29 (1.27)
Girls rejecting physics	104	8.61 (2.19)**	4.95 (1.14)**

* $p < 5\%$ (t-test)
** $p < 1\%$ t-test)

Overall, boys show the better general disposition towards physics and find the subject less of a 'slog'. These differences are still maintained when the analysis is restricted to A-level physics choosers.

There are no sex differences for those rejecting the subject.

It is unsurprising to find that the physics choosers, whether boys or girls, are more positively attracted to the subject and find it less of a 'slog' than do those who reject it.

7.5.5. SEX DIFFERENCES IN COMPARATIVE SUBJECT ATTITUDES

The construct scale responses for each subject were analysed by sex. To judge the significance of the differences in scale scores, the Wilcoxon 'W' statistic was considered to be the most appropriate. The S.P.S.S. statistical package (U.M.R.C.C., 1979) calculates a normally distributed z-statistic from 'W' and its corresponding probability. Tables 7.5.13 to 7.5.21 show the differences.

TABLE 7.5.13. SEX DIFFERENCES IN ATTITUDES TO FRENCH

Construct scale	Mean score boys (N=276)	Mean score girls (N=150)	Level of significant difference in favour of boys, B or girls, G
Interest	1.76	2.25	<< 1% G
Too much material	1.76	1.54	< 5% B
Difficult	2.32	2.04	<< 1% B
Boring	2.43	2.14	<< 1% B
Modern	2.38	2.52	NS
Low prestige	2.01	1.69	<< 1% B

TABLE 7.5.14. SEX DIFFERENCES IN ATTITUDES TO PHYSICS

Construct scale	Mean score boys (N=485)	Mean score girls (N=170)	Level of significant difference in favour of boys, B, or girls, G
Interest	2.44	2.18	<< 1% B
Too much material	1.83	2.09	< 1% G
Difficult	2.44	2.62	< 5% G
Boring	1.88	2.15	<< 1% G
Modern	2.63	2.42	<< 1% B
Low prestige	1.47	1.49	NS

TABLE 7.5.15. SEX DIFFERENCES IN ATTITUDES TO GEOGRAPHY

Construct scale	Mean score boys (N=338)	Mean score girls (N=93)	Level of significant difference in favour of boys, B, or girls, G
Interest	2.36	2.57	NS
Too much material	1.84	1.96	NS
Difficult	1.75	1.79	NS
Boring	1.98	1.80	NS
Modern	2.50	2.61	NS
Low prestige	1.96	1.95	NS

TABLE 7.5.16. SEX DIFFERENCES IN ATTITUDES TO BIOLOGY

Construct scale	Mean score boys (N=200)	Mean score girls (N=125)	Level of significant difference in favour of boys B, or girls G
Interest	2.77	2.78	NS
Too much material	1.63	1.62	NS
Difficult	1.84	1.61	<5% B
Boring	1.61	1.50	NS
Modern	2.77	2.76	NS
Low prestige	1.57	1.58	NS

TABLE 7.5.17. SEX DIFFERENCES IN ATTITUDES TO ENGLISH LITERATURE

Construct scale	Mean score boys (N=341)	Mean score girls (N=147)	Level of significant difference in favour of boys B, or
Interest	2.01	2.31	<< 1% G
Too much material	1.81	1.68	NS
Difficult	2.02	1.84	< 5% B
Boring	2.29	2.03	< 1% B
Modern	1.80	2.02	< 1% G
Low prestige	1.91	1.82	NS

TABLE 7.5.18. SEX DIFFERENCES IN ATTITUDES TO CHEMISTRY

Construct scale	Mean score boys (N=352)	Mean score girls (N=123)	Level of significant difference in favour of boys B, or girls G
Interest	2.46	2.56	NS
Too much material	1.96	1.81	NS
Difficult	2.34	2.26	NS
Boring	1.80	1.70	NS
Modern	2.63	2.64	NS
Low prestige	1.55	1.55	NS

TABLE 7.5.19. SEX DIFFERENCES IN ATTITUDES TO MATHEMATICS

Construct scale	Mean score boys (N=483)	Mean score girls (N=171)	Level of significant difference in favour boys B, or girls, G
Interest	2.50	2.52	NS
Too mu c h material	1.53	1.36	< 5% B
Difficult	1.94	1.95	NS
Boring	1.88	1.86	NS
Modern	2.69	2.66	NS
Low prestige	1.40	1.43	NS

TABLE 7.5.20. SEX DIFFERENCES IN ATTITUDES TO HISTORY

Construct scale	Mean score boys (N=202)	Mean score girls (N=68)	Level of significant difference in favour boys B, or girls, G
Interest	2.37	2.43	NS
Too much material	1.88	1.91	NS
Difficult	1.76	1.74	NS
Boring	1.90	1.85	NS
Modern	2.06	2.07	NS
Low prestige	2.01	1.90	NS

TABLE 7.5.21. SEX DIFFERENCES IN ATTITUDES TO ENGLISH LANGUAGE

Construct scale	Mean score boys (N=488)	Mean score girls (N=171)	Level of significant difference in favour boys, B or girls, G
Interest	2.22	2.35	NS
Too much material	1.30	1.22	NS
Difficult	1.56	1.53	NS
Boring	2.04	2.02	NS
Modern	2.42	2.46	NS
Low prestige	1.61	1.77	< 5% G

In tables 7.5.13 to 7.5.21, NS indicates no significant difference between the boys and girls responses.

Table 7.5.13 confirms the marked antipathy of boys towards French. The more positive attitudes shown by boys towards physics (table 7.5.14) has already been noted. Geography, chemistry and history are notable in so far as these subjects show no attitudinal sex differences. Just as physics appears as a 'male' subject, English literature appears as 'female', with the girls reversing their attitudinal responses. Sex differences for English language and mathematics appear minor, but even if biology is practically a 'neutral' subject, girls do find it easier than boys.

7.5.6. CONCLUDING REMARKS

The attitude analysis reported here demonstrates statistically sound subject rank-orders on a number of constructs. French and English literature appear as 'female' subjects, showing a consistently greater appeal to the girls of the survey sample. Physics is the only predominantly 'male' subject. The sex-typing of these three subjects agrees with Ormerod's findings with samples of younger pupils, although he did find it possible to 'label' other subjects too (Ormerod, 1975).

A notable difference between the findings of the present survey and those of Duckworth and Pell (Section 2.2) is that physics receives a much more favourable rating by boys than might be expected, with the subject consistently joining chemistry and mathematics in a 'top three' grouping. The source of this difference could well lie in the nature of the survey samples. The current research draws data specifically from physics classrooms where participation had been volunteered by the senior physics teachers. It is reasonable to suppose that many teachers whose classes showed attitudes towards physics which were much less positive would have declined the opportunity to take part in the survey. The earlier surveys of Duckworth and Pell, although using smaller, opportunity samples, would have been more likely to have gathered the views of antipathetic classes because of the nature of their designs.

If there is a bias in the sample surveyed towards a more positive view of physics, this enhances even more the major finding of the current work, namely, that physics is rated the most difficult of the subjects by both boys and girls. This result confirms the outcomes of earlier surveys with smaller, less representative samples (Hockey and McKim, 1968; Duckworth, 1972, and Pell, 1977). The additional discovery that A-level physics choosers, both boys and girls, also rate the subject as either the most or second most difficult subject of all raises questions on the conceptual levels of understanding required by O-level physics courses. Attention to this problem has been drawn previously by Duckworth and Entwistle (1974b) and Pell (1977). It is hoped that G.C.E. syllabus revision associated with any common system of examining (T.E.S., 1978) will take into account the growing collection of evidence on the theme of subject difficulty.

Physics is seen to be poorly rated by girls, notwithstanding any sample bias. This strongly supports the hypothesis that differential influences are at work on the two sexes in physics education. The relative unpopularity of physics with girls is a well known phenomenon (Section 2.4), and the introduction of new curricula has apparently had little influence on overall trends (Harvey, 1980). It is clear from Sections 7.2.3 and 7.4.4 that girls' attainment in physics is associated with subject enjoyment and the style of teaching. Table 5.5.4 gives further evidence for the attitude-attainment link. To improve the image of physics amongst girls, generally, it appears that a positive methodology of teaching for enjoyment (Section 7.4.4), firstly, and teaching new subject content, secondly, has much to recommend it.

Not all girls have a poor impression of physics, however. Girls choosing to study A-level physics find that subject more interesting than any other subject apart from chemistry. Indeed, girls choosing A-level physics act more like boys (table 7.5.11) which supports the earlier findings of Walberg(1969a) and Duckworth (1972). Even so, mathematics, chemistry and biology are generally more attractive to the physics choosing girls (Appendix 7.5.1).

Scores on the two composite physics attitude scales of 'satisfaction' and 'slog' confirm the gender of the subject (table 7.5.12). However, sex differences only appear between the A-level physics choosers, with the girls expressing less 'satisfaction' and finding the subject more of a 'slog'. It seems that the 'masculine' behaviour of girls referred to in the preceding paragraph applies to comparative subject attitudes: real differences do exist in intrinsic attitudes to physics. The 'slog' factor is more substantial for the girls with difficulty showing a greater association with overloaded subject content (table 7.5.8). Girls generally see physics as the most overloaded subject of all.

In absolute terms, the course content for both boys and girls might be expected to be the same, so, it is reasonable to ask why girls see physics as so overloaded and hence feel it is so much of a 'slog'. The answer might be that the girls have not developed sufficiently strong conceptual links to form effective problem-solving or thinking strategies to enable them to rationalise the subject content - to see where and how the facts of the subject fit together. The girls' deficiencies in such a learning style (Gagné, 1970) cause them to see physics as an apparently disorganised field of knowledge, consisting of discrete conceptual entities without any ordering pattern to assimilate understanding. Such a hypothesis is consistent with the view (Saraga, 1975 and Section 2.4) that boys generally have better developed problem-solving abilities than girls, who in turn have superior verbal abilities. Thus, although the inherent difficulty of physics as a discipline is acknowledged by boys and rated accordingly, their better problem-solving skills allow them to organise the subject-matter more effectively than the girls and hence, they see the subject as less overloaded in content.

Further support for thinking-ability differences between the sexes is given by considering the evidence from those girls that do choose A-level physics (table 7.5.10). For these girls, mathematics (one of Ormerod's 'male' subjects) is judged to be the easiest subject of all. This can be taken as a strong indication that spatial, analytical, and arithmetical abilities are well developed in these girls (Saraga, 1975). They will be expected to have developed problem-solving skills in physics, like many of the boys, and to have organised the subject content of the physics course. A further hypothesis can then be formulated that for girl physics choosers, physics is no longer seen as so overloaded in content, which is indeed confirmed by table A in Appendix 7.5.1.

Despite the difficulty of physics, a large proportion of pupils do continue to study the subject to A-level on a national scale (Section 1.2). Evidence that this is also true for the pupils in the present survey is given by table 7.5.12. Earlier research suggests that the reason for this would be the usefulness of physics as a career qualification, which is confirmed in Section 7.6. However, table 7.5.9 does show that there is a strong intrinsic interest in physics amongst

A-level choosers , which is a confirmation of Duckworth and Entwistle's earlier findings.

Regardless of differences in interest and perceived difficulty, the boys and girls are unanimous in expressing the view that physics, mathematics and chemistry are the most prestigious of the subjects. It can be argued that the 'prestige' construct as used in the current research is open to some misinterpretation. Yet, the question must now be asked whether the addition of a social-implications dimension to science teaching, which has been variously discussed by educators and researchers (Ormerod with Duckworth, 1975; Harvey, 1980), will do much to encourage more pupils to opt for the physical sciences and to later enter scientific professions. The pupils in the current survey have made one choice, for physics, at the age of 13-14 years. At the age of 16 years, they still give the physical sciences the highest prestige ratings. It is difficult to see how this might be further improved by adding a social-implications dimension to the courses. One result of such an action, though, would be to change to some degree the nature of the learning required in the physical sciences, with a shift more towards verbal abilities, which would be expected to encourage girls, in particular, to make progress in a subject of lesser perceived difficulty and greater social relevance (Kelly, 1975). There would still be the problem of teaching the rigorous scientific content of this hybrid subject.

Science at school is difficult, and as Shayer and Adey (1981) have pointed out, some courses do require thinking skills beyond many of the pupils. While it is possible and desirable to postpone the teaching of some of the difficult concepts to post O-level, when they might then better match the pupil's cognitive development (Shayer, 1972, and Shayer and Adey, 1981), this form of curriculum development must respect the nature of the subject (Black, 1977). It is conceivable that the addition of a social implications factor would result in the teaching of a form of pseudo-physics which, for those pupils intending to move onto A-level studies, would then have to revert to 'normal' physics for which the pupils might be unprepared. Kelly (1975) argues that there might not be any need for science and physics to 'revert back', and social implications physics could attract more pupils, that is girls, at the 13-14 years-old choice stage.

Perhaps such a revolutionary change in the nature of physics taught to O-level is unnecessary. The present research has shown (Section 7.4) how the teaching environment can be modified to enhance subject attitudes and attainment. The subject is difficult, but concepts which cannot match the pupils cognitive development can be postponed, and subject content can always be reduced. The new London O-level physics course (University of London,1981) illustrates that it is possible to achieve the desirable aim of content reduction, so a sympathetic teaching style should be adopted that specifically encourages the development of analytical problem-solving skills (Saraga suggests the use of discussion techniques and Shayer and Adey suggest a greater use of individual learning methods). In this way, subject difficulty should be lessened. Whether such an approach would be suitable for all types of pupils is investigated further in Section 7.11.

7.6. CHOOSING A-LEVEL SUBJECTS

7.6.1. SUBJECTS STUDIED IN THE FIFTH-FORM

In all, some 43 different subjects were being studied by 677 pupils. A number of these subjects, for example rural studies, Spanish, social studies and Polish, attracted relatively few pupils and were unlikely to be pursued beyond the fifth-form stage. With little loss of significant data, it was decided to omit these minority subjects and to restrict the analysis to the 14 subjects which attracted more than 10 per cent of the pupils. Table 7.6.1 shows these subjects and the relative proportions of boys and girls studying them.

TABLE 7.6.1. THE FOURTEEN MAJOR FIFTH-FORM SUBJECTS

Subject	Percentage of pupils studying the subject		
	All pupils (N = 657)	Boys (N = 485)	Girls (N = 172)
Art	13.1	11.1	18.6*
Biology	48.9	41.0	71.3*
Chemistry	71.1	71.3	70.3
English language	84.8	81.8	93.0
English (C.S.E.)	13.1	15.5*	6.4
English literature	71.8	67.4	84.3*
French	63.9	56.3	85.5*
Geography	64.1	67.6*	54.1
Geometrical and Mechanical Drawing (G.M.D.)	20.7	27.0*	2.9
German	16.4	12.8	26.7*
Handicraft	25.1	30.7*	9.3
History	40.6	41.4	38.4
Mathematics	93.9	93.0	96.5
Physics	100.0	100.0	100.0

By comparing the actual number of boys and girls taking a subject with the number expected, given a sex ratio of 485 boys to 172 girls, the differences between the sexes can be investigated for statistical significance. The χ^2 - statistic is employed for this raw score analysis (although percentages only are shown) and an asterisk in the respective column indicates when a significance level of 5 per cent is achieved in favour of either the boys or the girls.

The most notable conclusion to be drawn from table 7.6.1 is the distinct 'female' nature of the linguistic subject grouping of French, English literature and German, as well as the expected female support for biological science.

7.6.2. RELATIVE SUBJECT ENJOYMENT

Two approaches were adopted to obtain rank orders for subject enjoyment. The first required a count of the number of times a subject appeared in the 'most enjoyed subject' category. The second was merely a record of the number of times the subject appeared anywhere in the top three ranking order. A preliminary analysis suggested that sex differences were present, and tables 7.6.2 and 7.6.3 show the enjoyment ranks broken down by sex. In each table the percentage rating is derived from the sub-group of pupils actually studying that subject.

In expressing their enjoyment of English, pupils sometimes did not distinguish between English language and English literature. Consequently, enjoyment values for these two subjects are to be found somewhere in the indicated range: probably nearer to the lower figure than the higher one.

TABLE 7.6.2. THE MOST ENJOYED SUBJECTS : RANK ORDERS

Boys				Girls			
Subject		Percentage rating subject 'most' enjoyed'	χ^2	Subject		Percentage rating subject 'most enjoyed'	χ^2
Art	**	49.1	45.0	Art	**	34.4	12.1
Handicraft	**	40.4	69.8	Biology	**	26.4	20.7
Biology	**	24.1	23.2	G.M.D.		20.0	NS
G.M.D.		18.3	NS	History		19.7	NS
History		16.4	NS	Maths	*	17.6	4.11
Maths		15.1	NS	Chemistry		13.3	NS
Geography		10.4	NS	Handicraft		12.5	NS
Physics	*	9.9	4.30	Geography		12.0	NS
Chemistry		9.6	NS	German		10.9	NS
German		6.5	NS	French		8.2	NS
French	*	2.9	21.8	Physics	*	2.9	13.0
English language	*	5.6-12.1	18.3-NS	English lit.	*	4.9-9.7	7.0-NS
English lit.	*	2.8-10.7	27.7-NS	English language	*	1.9-6.2	14.3-4.3

For one degree of freedom, a significant difference at the 5% level exists if $\chi^2 > 3.84$. NS indicates 'not significant'. A double asterisk indicates a popular subject: a single asterisk indicates an unpopular one.

To judge the significance of the rating percentages, the χ^2- statistic was used to compare the number of times a subject appeared as 'most enjoyed' with its expected chance occurrence. An actual example best illustrates the technique employed.

The 54 boys studying art comprise
one taking four subjects,
five taking five subjects,
six taking six subjects,
ten taking seven subjects,
twenty five taking eight subjects,
six taking nine subjects
and one taking ten subjects

For the boy taking four subjects, there is a one in four chance that art will appear as 'most enjoyed'. Those taking seven subjects, have a one in seven chance of choosing art, if the selection was done purely on a random basis. Overall, the number of times art might be chosen by chance is:

$$(1 \times \tfrac{1}{4}) + (5 \times \tfrac{1}{5}) + (6 \times \tfrac{1}{6}) + (10 \times \tfrac{1}{7}) + (25 \times \tfrac{1}{8}) + (6 \times \tfrac{1}{9}) + (1 \times \tfrac{1}{10})$$

or 7.7 times (the integral value of 8 would be used in the χ^2- test). The observed frequency of rating art 'most enjoyed' is actually 26, which, as table 7.6.2 shows, leads to a highly significant value of χ^2.

As the example above illustrates, in calculating χ^2 absolute numbers rather than percentages are employed.

Both boys and girls agree that art is the most enjoyable subject in the curriculum. Biology is highly enjoyed too. Handicraft (metalwork or woodwork) is very popular amongst the boys, as well. Few boys and girls strongly enjoy their physics. The girls rate this least attractive, but French is even more unpopular with the boys (compare this with the similar results in Section 7.5).

TABLE 7.6.3. THE THREE MOST ENJOYED SUBJECTS - RANK ORDERS

Boys			Girls		
Subject	Percentage rating subject as one of 'top three'	χ^2	Subject	Percentage rating subject as one of 'top three'	χ^2
Handicraft	75.0	59.5	Art	81.3	24.3
Art	71.7	18.2	Biology	66.1	45.0
Biology	53.8	22.7	History	51.5	5.9
Mathematics	50.0	21.0	Mathematics	50.3	13.2
History	47.3	8.1	German	43.5	NS
G.M.D.	43.5	NS	Geography	41.3	NS
Physics	43.4	NS	Chemistry	40.0	NS
Geography	40.4	NS	G.M.D.	40.0	NS
Chemistry	34.5	NS	Handicraft	31.3	NS
German	22.6	5.0	French	20.5	14.9
French	14.7	60.9	Physics	18.7	23.3
English lit.	15.0-41.0	70.4-NS	English lit.	13.8-36.1	31.4-NS
English language	14.6-36.1	93.3-NS	English language	8.8-28.9	51.2-NS

For one degree of freedom, a significant difference at the 5% level exists if $\chi^2 > 3.84$. NS indicates 'not significant'.

Table 7.6.3 shows that when second and third choice enjoyment preferences are taken into account, the ranking orders are strengthened with fewer non-significant ratings. This time the expected chance frequencies would be three times the values used in the significance test of table 7.6.2. Thus, taking the example with art again, the expected chance frequency of art in the 'top three' ratings of the 54 boys would be

$$(1 \times \frac{3}{4})+(5 \times \frac{3}{5})+(6 \times \frac{3}{6})+(10 \times \frac{3}{7})+(25 \times \frac{3}{8})+(6 \times \frac{3}{9})+(1 \times \frac{3}{10})$$

or 23.1 times. The integral value of 23 is then compared with an observed frequency of 39, in this instance, to give a χ^2- value of 18.2.

Comparing the results of table 7.6.3 with those of table 7.6.2 , it is clear that mathematics and history are highly rated by both sexes. However, if either art or biology are being studied too (or handicraft, in the case of boys), one or more of these subjects is likely to take precedence.

The dislike of physics amongst girls is confirmed by table 7.6.3, but for boys this subject now draws a stronger response. Amongst boys, physics receives a moderate enjoyment rating but significantly more do prefer another subject.

Table 7.6.3 gives evidence of the relative unpopularity of languages with the boys. The deterioration in the rating of French by the girls suggests that its barely moderate position in table 7.6.2 is due to the existence of a small minority of girls with whom the subject is highly popular.

7.6.3. POST O-LEVEL INTENTIONS

Table 7.6.4 shows the intended destinations of the pupls after the fifth-form examinations. Sex differences in these intentions were investigated with the χ^2- statistic.

TABLE 7.6.4. POST-EXAMINATION INTENTIONS

Intention	Boys (N=485)	Girls (N=172)	χ^2
To leave full-time education	122 (25.2 %)	21 (12.2%)	8.78
To start A-levels including physics	221 (45.6%)	45 (26.2%)	11.63
To start A-levels excluding physics	121 (24.9%)	104 (60.4%)	45.49
To remain in full-time education but not to start A-levels	21 (4.3%)	2 (1.2%)	2.76

For one degree of freedom, a significant difference at the 5% level exists if χ^2 > 3.84

Although a significantly greater proportion of boys intend to leave full-time education altogether after the external examinations, almost half do intend to remain to study A-level physics. Considering the poor enjoyment rating given to physics by the girls, it is no surprise to see the strength of their rejection of the subject at A-level.

7.6.4. A-LEVEL SUBJECT CHOICE - FREE AND 'BOUND'

Table 7.6.5 shows the A-level subject choice preferences under the 'free'and 'bound' conditions. Of the three English subjects appearing in tables 7.6.2. and 7.6.3, only English literature remains relevant in the A-level choice context.

The calculation of the choice preferences is done by expressing the number choosing the subject as a proportion of the number studying the subject at fifth-form level.

TABLE 7.6.5. BOYS' CHOICES OF A-LEVEL SUBJECTS

Subject	Free choice preference (%) First choice	Second choice	Third choice	Total	Bound choice (%)	Probability that difference in choices is due to chance
Art	18.5	5.6	13.0	37.0*	16.7	< 0.01
Biology	18.6	11.6	11.6	41.7*	33.2	< 0.01
Chemistry	7.5	11.3	11.3	30.1	34.2	0.04
English literature	8.6	11.3	6.7	26.6	26.6	0.87
French	2.6	2.9	2.6	8.1	6.6	0.34
Geography	6.1	9.2	9.2	24.5	17.5	≪ 0.01
German	4.8	3.2	11.3	19.3	12.9	0.22
G.M.D.	7.6	4.6	9.2	21.4	19.8	0.81
Handicraft	2.1	1.5	1.5	5.2*	4.0	0.34
History	10.0	6.0	8.5	24.4	17.4	0.01
Mathematics	18.7	16.2	12.9	47.8*	52.7	< 0.01
Physics	12.8	14.2	10.1	37.2*	45.6	≪ 0.01

* p < 5%

TABLE 7.6.6. GIRLS' CHOICES OF A-LEVEL SUBJECTS

Subject	Free choice preference (%) First choice	Second choice	Third choice	Total	Bound choice (%)	Probability that difference in choices is due to chance
Art	18.8	15.6	21.9	56.3*	31.3	0.02
Biology	28.1	14.0	19.8	62.0*	49.6	< 0.01
Chemistry	10.0	14.2	14.2	38.3	44.2	0.12
English literature	10.4	13.2	11.8	35.4	33.3	0.63
French	9.6	8.2	6.8	24.7	18.5	0.02
Geography	10.9	15.2	14.1	40.2	25.0	0.39
German	6.5	13.0	15.2	34.8	34.8	1.00
G.M.D.	-	-	-	-	-	-
Handicraft	12.5	0	0	12.5	12.5	1.00
History	15.2	18.2	13.6	47.0*	39.4	0.18
Mathematics	15.8	15.2	13.3	44.2*	45.5	0.82
Physics	2.3	2.9	8.8	14.0*	26.2	≪ 0.01

* p < 5%

The significance of a free choice preference in tables 7.6.5 and 7.6.6 is indicated by an asterisk when the total preference percentage differs from the chance value at the 5% probability level (the calculation is explained in some detail in Appendix 7.6.1). Once more the χ^2- statistic is used for the significance test. Subjects positively rejected at A-level, given a free choice are handicraft by the boys and physics by the girls.

Bound choices were compared with 'total' free choices by means of the non-parametric 'sign' statistic (Siegel, 1956). The probability that the difference in choices is due to chance appears in the final column of the table.

Subjects which gain in apparent popularity under 'bound' choice conditions are, for boys, those comprising the classical science combination of mathematics, physics and chemistry. Girls, however, are 'pressed' into taking one subject only, physics. Both boys and girls are forced to modify their choices of art and biology significantly. In addition, boys have to modify their preferences for geography and history, while girls do the same for French.

In terms of real or 'bound' subject preference, the 'top 3' subjects for boys are mathematics, physics and chemistry, but for the girls, biology easily displaces physics. Table 7.6.7 shows the relative numbers of pupils choosing the possible science subject groupings under 'bound' conditions.

TABLE 7.6.7. A-LEVEL SCIENCE COMBINATIONS

Science subject combination	Number of pupils choosing the combination		χ^2
	Boys	Girls	
Mathematics, physics, chemistry	76	17	5.63
Mathematics, physics, biology	17	6	NS
Physics, chemistry, biology	26	14	NS
Mathematics, chemistry, biology	2	9	13.86
Physics, non-science subjects	102	8	25.98

Taking the numbers from table 7.6.4 for boys and girls intending to study A-level subjects, 342 and 149 respectively, sex bias in the science subject combinations can be investigated by the χ^2- statistic. The 5% significance level is given by a value of 3.84. (NS indicates no significant difference),

It is clear that the traditional mathematics-physics-chemistry combination is male biased; as is the tendency to combine physics with non-science subjects. The mathematics-chemistry-biology combination, although relatively uncommon, is the only one with a female bias.

7.6.5. A-LEVEL SUBJECT CHOICE AND ENJOYMENT

Free choice preferences were compared with subject enjoyment rankings. These are shown for boys and girls separately in tables 7.6.8 and 7.6.9.

TABLE 7.6.8. BOYS' PREFERENCES AND ENJOYMENT

Subject Enjoyment	A-level subject preference: First choice	Second choice	Third choice
Most enjoyed	199	35	24
Second most enjoyed	56	134	52
Third most enjoyed	21	65	112

TABLE 7.6.9. GIRLS' PREFERENCES AND ENJOYMENT

Subject enjoyment	A-level subject preference: First choice	Second choice	Third choice
Most enjoyed	114	13	8
Second most enjoyed	16	79	20
Third most enjoyed	7	23	56

The strength of the association between subject enjoyment and preference for A-level study can be expressed by means of the contingency coefficient, C. (Siegel, 1956, p.196). The values for this correlation coefficient for boys and girls respectively, are 0.56 and 0.66, both of which are significantly different from zero (at probability levels of much less than 1%). In interpreting the sizes of the correlations it must be taken into account that the maximum value of C for a 3 x 3 contingency table is 0.82.

While it is possible to construct a more extensive contingency table including categories like 'most enjoyed but not chosen', and 'not in top three enjoyment rank but a first choice preference', the allocation of responses to these categories leads to somewhat ambiguous interpretations. For instance, English language simply cannot be chosen at A-level although it might get a high enjoyment rating, yet pupils in this category will find themselves joined by others who rate and choose subjects for quite different reasons. Also, first choice preferences can be drawn from some subjects which were not available in the fifth-form classes, for example economics, computer science and general studies. By using the simplified 3 x 3 tables, the correlations between enjoyment and preference tend to be an overestimate of the association because of the mechanics of the A-level choice process.

7.6.6. CONCLUDING REMARKS

The results of the present survey support the findings of the earlier work of Selkirk (1972), Pell (1975) and Wilkinson(1975). There is an association between subject choice at A-level with subject enjoyment and there are significant differences between subject choices in 'free' and 'bound' situations.

For both boys and girls, biology is one of the two most popular A-level subject choices. Yet, when asked to consider possible constraints, significant numbers of pupils have to change their preferences. The results of table 7.6.2 show the attractiveness of biology to the pupils at fifth-form level in the current research sample, so science educators might feel disturbed with this phenomenon where a popular science has to be rejected. This finding is not original: the earlier work of Pell (1975) revealed a similar trend. Appendix 7.6.2 shows which subjects boys and girls opt for when their choice is constrained if they cannot take biology. Mathematics and physics are the subjects which are seen to benefit.

In Section 7.5, reference was made to the surprisingly strong interest rating that physics received from the boys in relation to most of the other academic subjects.

Tables 7.6.2 and 7.6.3 show that this is not translated into a correspondingly strong enjoyment rating. For boys, physics occupies a place in the lower half of the subject 'merit' order. Unsurprisingly from the results of Section 7.5 and earlier research, for the girls physics is almost certainly the least liked subject (the slight qualification arises from the uncertainty in the ratings of the two English subjects).

Having demonstrated that choice of an A-level subject is associated with subject enjoyment and the relative enjoyment of physics is low , it is clear that steps taken to improve the enjoyment of physics might reasonably be expected to increase the numbers of pupils choosing A-level physics 'freely'. How enjoyment might be improved is explained elsewhere in Sections 5.2.3 and 7.4.4. The situation in the present research is that there is still a significant proportion of physics pupils being 'pressed' into the study of the subject at A-level against their attitudinal feelings. Selkirk's 38 percent of 'pressed' physics students can be compared with figures of 18 percent and 47 percent for boys and girls, respectively, from tables 7.6.5 and 7.6.6. There is little real evidence here that the 'pressed' student effect has been reduced over the time-span of some eight years between the two surveys, but a firm conclusion is hazardous as Selkirk did not supply a sex-breakdown for his findings, which were drawn from actual rather than potential sixth-formers.

Perhaps the most satisfactory procedure is to compare the present results with those collected by the author (Pell,1975) some four years earlier from four schools in another part of the country. This earlier survey found that, amongst potential sixth-formers, 25 percent of boys and 8 percent of girls are pressed into taking A-level physics. There is a considerable fluctuation here in the figure for the girls, which might be a reflection of the nature of the school composition of the two samples (a higher proportion of the girls in the earlier survey was drawn from single-sex schools, where the girls tend to show a superior satisfaction with the physical sciences - Ormerod with Duckworth, 1975).

It is fair to conclude that the 'pressed-student' effect is probably no greater than it was almost a decade ago; that there might have been some reduction in the effect for the boys, but that there is a marked sex-interaction effect, which is now quite clear, and the situation for the girls remains disturbing.

It is difficult to determine the representativeness of the sample in the present survey despite the varied nature of the participating institutions. One test is to start from the data base of table 7.6.4 and to compare A-level physics take-up rates with national norms. Adding details of G.C.E. performance (Appendix 7.6.3) yields the information that 67% of the boys and 45% of the girls who pass the O-level physics examination intend to take A-level in the subject. The technique of comparing A-level subject passes two years earlier was introduced in Section 1.3. The recent trend in physics is for the porportion of A-level entries to become approximately constant after falling almost continually from a high plateau in the early nineteen-sixties (figure 1.3.1). The latest statistics available from Department of Education and Science (D.E.S., 1981) show proportions of 58 percent and 46 percent for boys and girls, respectively. The actual take-up figures in the present survey sample could be an overestimate for two reasons. Firstly, some pupils may not embark on the A-level course, despite their expressed intentions, possibly because of re-organised career plans following the O-level examinations. Secondly, all pupils beginning the A-level course do not necessarily complete it. Taking these factors into account, the survey sample does not seem untypical of schools generally in this respect, although Appendix 7.6.3 shows that the sample could be of a higher ability than normally expected.

The elementary nature of the subject choice grid suggest that interested teachers might want to contribute, through the organisation of the Association for Science Education for example, to a national pool of data. This would permit the stability of the subject enjoyment patterns found in the current research to be monitored and the impact of curriculum change to be evaluated. The worth of such an evaluation system would be demonstrated if physics were to be made more attractive, especially for the girls. Would more pupils choose to study it in the sixth-form and would the 'pressed-student'effect be reduced?

7.7. REASONS FOR CHOOSING OR REJECTING PHYSICS AT A-LEVEL

7.7.1. CHOOSING A-LEVEL PHYSICS - PATTERNS IN THE RESPONSES

The frequency distribution for the 16 check-list items has been briefly reported in Section 5.7.2. Figure 7.7.1 shows this distribution in greater detail and distinguishes between the ratings of the more important items. To help interpret the frequency distribution, a factor analysis of the responses to the 16 items was performed.

A varimax orthogonal solution (Section 2.9) identified six factors with eigenvalues more than unity accounting for 58% of the total variance. Some significant intercorrelation was suspected between the factors, which was confirmed when an oblique rotation of the factor axes was performed. The resulting factor structure matrix appears in Appendix 7.7.1.

The factors are:

FACTOR 1C: Physics will be easy to pass at A-level: it was easy at O-level (statements 7, 10 and 11).

FACTOR 2C: Confidence in tackling a difficult A-level course (statements 14 and 15).

FACTOR 3C: A good O-level performance (statements 1 and 2).

FACTOR 4C: The subject is educationally attractive, being experimental, attractively taught at

1. You have a high O-level physics grade
2. You have a better grade in physics
3. University and/or career requirements
4. Not a main subject: decided by timetable
5. The O-level course was interesting
6. You have heard the A-level course is interesting
7. The O-level course was easy
8. Allows mathematical ability to be expressed
9. Attracted by experimental work
10. Not so much hard work in A-level physics
11. Easier to pass in A-level physics
12. Attracted by A-level teaching methods in physics
13. Attracted by A-level physics examinations
14. More difficult to pass in A-level physics but confident
15. More hard work but confident
16. To improve your understanding of science in the world today

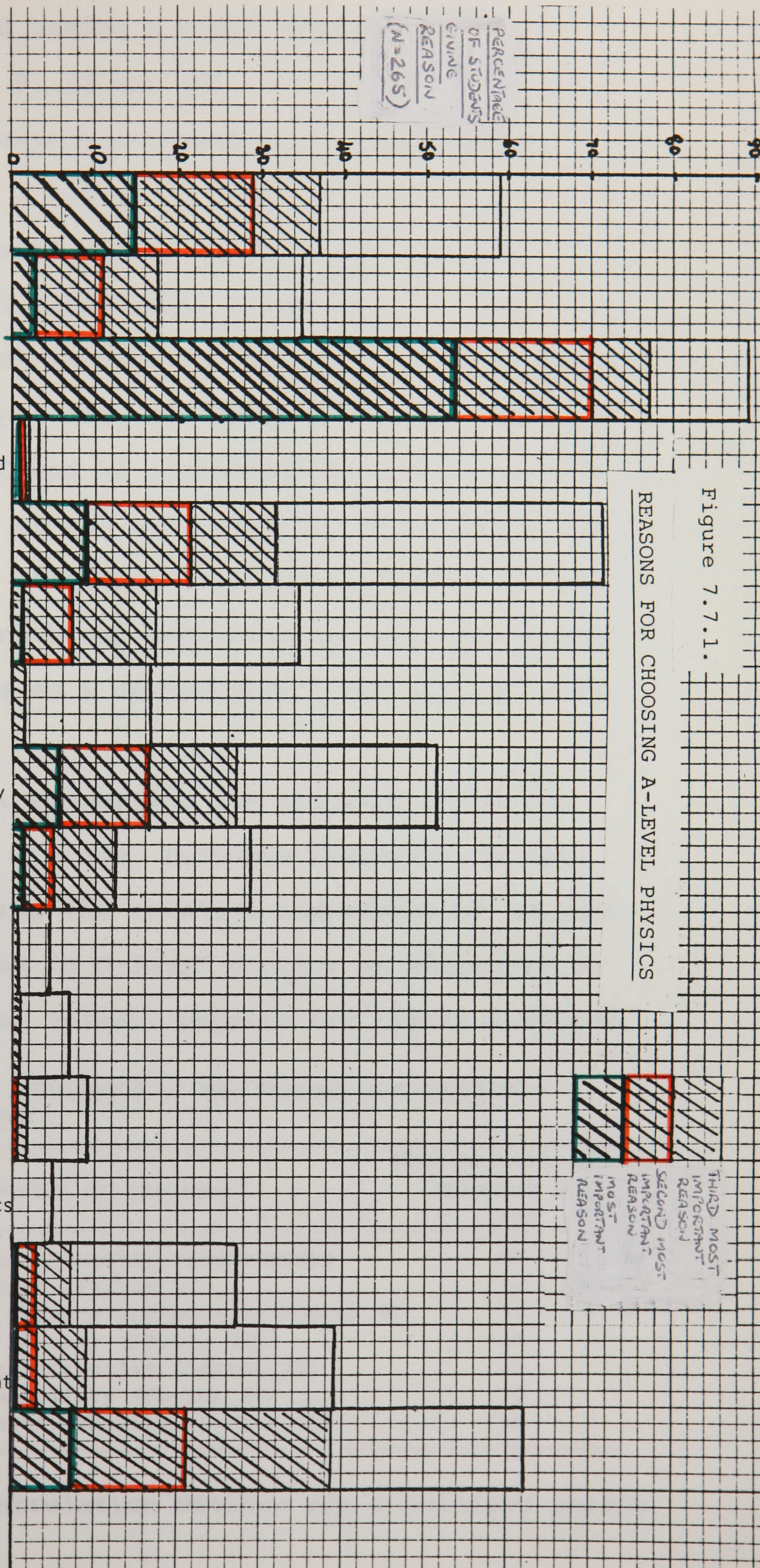


Figure 7.7.1.
REASONS FOR CHOOSING A-LEVEL PHYSICS

A-level, and having a wider significance (statements 9, 12 and 16).

FACTOR 5C: Intrinsic subject interest at O- and A-level (statements 5 and 6)

FACTOR 6C: An easy O-level course and the subject is mathematical (statements 7 and 8).

The strongest inter-correlations, at significant values of about 0.2 ($p < 1\%$), are found between factors 1C and 4C, and factors 2C and 5C (Appendix 7.7.2).

The absence of the most highly rated reason, the 'career requirements' statement 3, from the factor pattern demonstrates the strength and uniqueness of this one reason amongst all the others as a determinant of A-level physics choice.

Table 7.7.1. summarises the analysis of choice reasons by giving the average response frequency in each choice area. It confirms the relative importance of subject interest and attainment in O-level physics as secondary to the major need to take A-level physics for career purposes.

TABLE 7.7.1. THE RELATIVE IMPORTANCE OF THE REASONS FOR CHOOSING A-LEVEL PHYSICS

Factor or statement	Mean percentage response per item
University and/or career requirements	89
Subject interest (Factor 5C)	54
Good O-level physics performance (Factor 3C)	47
Mathematical ability (Factor 6C)	34
Educationally attractive (Factor 4C)	33
Confidence in ability (Factor 2C)	33
High intellectual ability (Factor 1C)	10

The inter-correlation between the subsidiary choice reasons of factors 1C and 4C suggests that pupils who find physics very easy and well within their capabilities also tend to welcome the 'nature of science' approach, in so far as this is defined by Factor 4C.

7.7.2. REJECTING A-LEVEL PHYSICS - PATTERNS IN THE RESPONSES

Figure 7.7.2 shows the distribution of responses earlier referred to in Section 5.7.2. Again, a factor analysis of the responses was performed to help in the interpretation.

This time the varimax solution showed that five factors had eigenvalues greater than unity accounting for 56% of the total variance. An oblique rotation of the factor axes gave the factor structure matrix of Appendix 7.7.3.

The factors are:

FACTOR 1R: An uninteresting, narrow subject, unattractively taught with insufficient experimental work (statements 5, 6, 9, 12, 13, 14 and 15)

FACTOR 2R: A low grade in a difficult subject (statements 1, 2 and 7)

FACTOR 3R: Too mathematical a subject (statements 8 and 16).

FACTOR 4R: A difficult A-level exam at the end of a hard course (statements 10 and 11).

FACTOR 5R: Career and timetable reasons (statements 3 and 4).

Factor inter-correlations are generally stronger

1. You have a low O-level physics grade
2. Your physics grade is lower than grades in other subjects
3. University and/or career requirements
4. Not main subject and timetable difficulties
5. O-level course not interesting
6. Heard that A-level course is not interesting
7. O-level course was difficult
8. O-level course was too mathematical
9. Not enough experimental work in O-level course
10. Harder work in A-level physics
11. More difficult to pass in A-level physics
12. Not attracted by A-level teaching
13. Not attracted by type of A-level physics exam
14. No room for personal views
15. Too narrow and specialist
16. A-level course is too mathematical

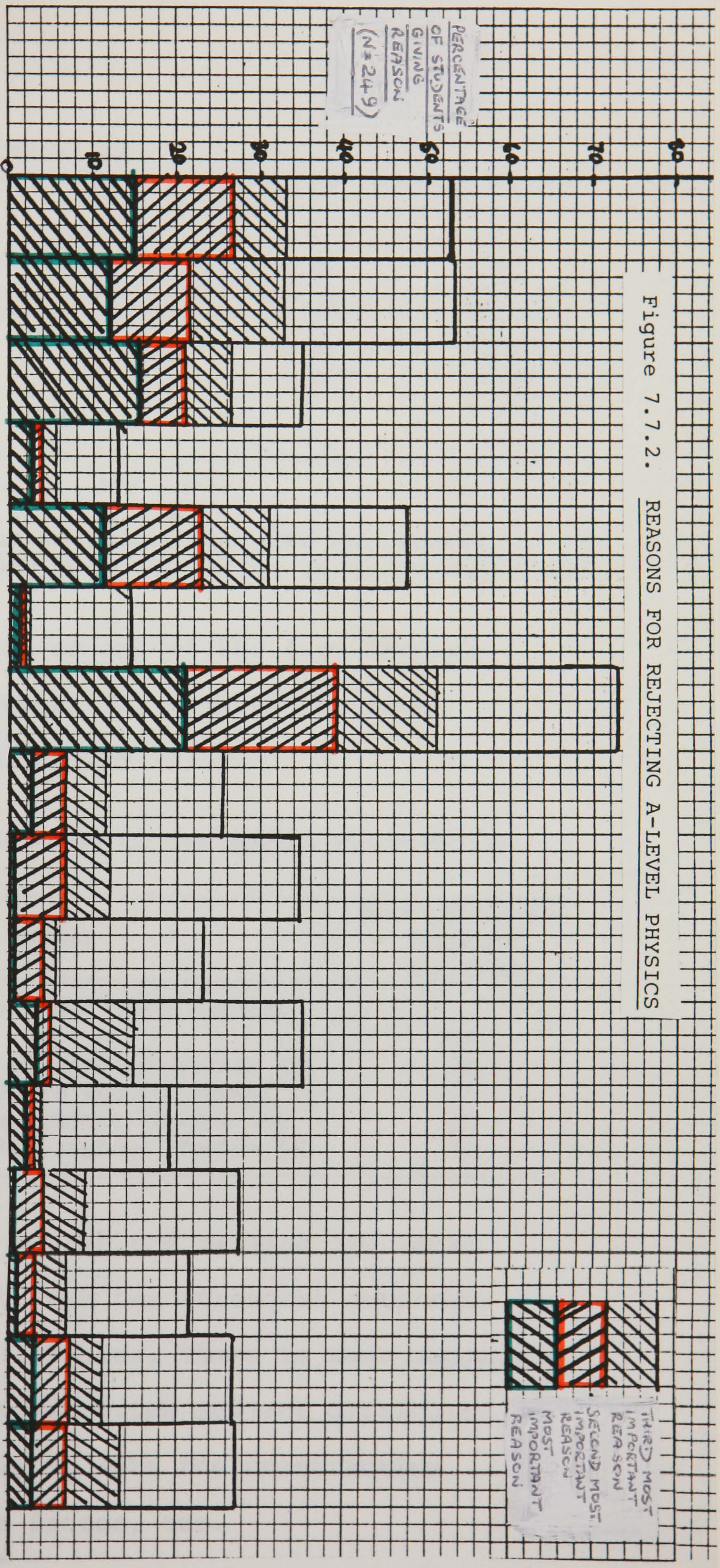


Figure 7.7.2. REASONS FOR REJECTING A-LEVEL PHYSICS

as table 7.7.2. shows.

TABLE 7.7.2. FACTOR INTER-CORRELATIONS

Factor	Factor 2R	3R	4R	5R
1R	0.20**	0.24**	0.21**	0.15*
2R		0.12	0.12	-0.18**
3R			0.24**	0.13*
4R				0.11
5R				

**p < 1%;
*p < 5%
The signs of the inter-correlations take into account the reversed scoring of factors 2R and 3R in Appendix 7.7.3.

All 16 items load on one of the five factors. The average response frequency for each of the five rejection areas is given in table 7.7.3.

TABLE 7.7.3. THE RELATIVE IMPORTANCE OF THE REASONS FOR REJECTING A-LEVEL PHYSICS

Factor	Mean percentage response per item
Low achievement in a difficult subject (Factor 2R)	60
Perceived A-level difficulty (Factor 4R)	29
All-round unattractive subject(Factor 1R)	27
Too mathematical a subject (Factor 3R)	27
Career and timetable reasons (Factor 5R)	24

Subject difficulty and the related low level of achievement are seen to form the strongest deterrent to the choosing of A-level physics. There is some suggestion from table 7.7.2 that pupils giving subject difficulty as a reason are also likely to rate the unattractive nature of the subject as a factor, too.

The correlation of all the factors with factor 1R points to the element of an unattractive, disliked subject in all the rejection areas. The rejection of physics because of career or timetable reasons (factor 5R) is apparently done with this antipathy in mind, and not because of subject difficulty or poor attainment (the negative correlation in table 7.7.2).

A further notable correlation is between the perceived mathematical nature of physics and expected difficulty in the A-level course.

7.7.3. SEX DIFFERENCES IN THE RESPONSES

The responses to the 16 check-list items were analysed separately for boys and girls. This analysis was performed for both 'choosers' and 'rejectors'. Appendix 7.7.4 shows the detailed breakdown but items for which there are significant sex differences appear in table 7.7.4.

TABLE 7.7.4. SIGNIFICANT DIFFERENCES BETWEEN THE SEXES

Choice (C) or Rejection (R)	Statement	Response frequency (%) Boys (N=143)	Girls (N=106)
C	7. The O-level course was easy	19	2**
R	3. University and/or career requirements mean other subjects must be studied	41	26*
R	4. It would not have been a main subject and it could not be fitted into school/college timetable	18	6**
R	6. You have heard that the A-level course is not interesting	20	7**
R	8. The O-level course was too mathematical	32	17*
R	9. There was not enough student experimental work in the O-level course	44	22**
R	16. The A-level course seems to have too much mathematics in it	34	18**

For choice statement 7, N=220 for boys and N=45 for girls
**$p < 1\%$; *$p < 5\%$ (χ^2- test on raw data)

All seven statements are male oriented. It is notable that it is the boys who are more likely to reject physics because of its perceived mathematical content (rejection factor 3R, statements 8 and 1) and because of a lack of experimental work (statement 9). The extrinsic career and timetable factor 5R (statements 3 and 4) is also seen to be more important a determinant for the boys. When choosing physics, the boys are more likely to do this because they have found the O-level course easy.

7.7.4. THE THREE MOST IMPORTANT REASONS

Ratings of the three most important check-list reasons appear in figures 7.7.1 and 7.7.2. These ratings tend to follow the frequency distributions for the complete check-lists, with 'career requirements' easily being the most important reason for choosing physics and with 'O-level course difficulty' being the most important rejection reason. Tables 7.7.5 and 7.7.6 show breakdowns of the responses by sex. Sex differences were analysed by the χ^2- statistic using the raw scores.

TABLE 7.7.5. THE THREE MOST IMPORTANT REASONS FOR CHOOSING PHYSICS

Statement	Frequency of response (%)			
	Boys (N=229)		Girls (N=45)	
	Most important	'Top three'	Most important	'Top three'
1. You have a high O-level physics grade	14	36	16	44
2. You have a better grade in physics than in most other subjects	3	18	2	18
3. University and/or career requirements	53	76	56	82
4. It is not a main subject but it was decided by school/college timetable	1	2	0	0
5. The O-level course was interesting	9	33	11	29
6. You have heard that the A-level course is interesting	1	16	2	20
7. The O-level course was easy	0	2	0	0
8. Physics allows you to use your mathematical ability	5	28	9	24
9. You are attracted by the amount of student experimental work in physics	1	14	2	7
10. Not so much hard work is expected in A-level physics as in other subjects	0	1	0	0
11. You have heard that it is easier to pass in A-level physics than in most other subjects	0	1	0	0
12. You are attracted by the A-level teaching methods in physics	0	2	0	0
13. You are attracted by the type of examinations in A-level physics	0	0	0	0
14. You have heard that it is more difficult to pass in A-level physics than in most subjects, but you are confident that you can manage	1	7	0	9
15. More hard work is expected in some other subjects but you think that you can manage	1	7*	0	20*
16. To improve your understanding of science in the world today	8	39	2	38

* $p < 5\%$ (χ^2)

TABLE 7.7.6. THE THREE MOST IMPORTANT REASONS FOR REJECTING PHYSICS

Statement	Frequency of response (%) Boys (N=143) Most important	'Top three'	Girls (N=106) Most important	'Top three'
1. You have a low O-level physics grade	18	31	10	36
2. Your physics grade is lower than the grades in most other subjects	9	31	16	35
3. University and/or career requirements mean other subjects must be studied	19	28	11	24
4. It would not have been a main subject and it could not be fitted into school/college timetable	4	7	1	4
5. The O-level course was not interesting	13	31	9	31
6. You have heard that the A-level course is not interesting	1	1	2	3
7. The O-level course was difficult	14**	45	30**	53
8. The O-level course was too mathematical	3	15	2	7
9. There was not enough student experimental work in the O-level course	1	17**	0	5**
10. You have heard that you must work much harder in A-level physics than in most other subjects	1	6	0	6
11. You have heard that it is more difficult to pass at A-level in physics than in most other subjects	4	14	2	16
12. You are not attracted by the teaching methods of the A-level physics course	3	5	1	2
13. You are not attracted by the type of A-level physics exam	1	9	0	9
14. A-level physics will not allow your personal opinions to be expressed	1	6	1	8
15. A-level physics is too narrow to be useful for you	3	11	3	11
16. The A-level course seems to have too much mathematics in it	11	17	5	9

** $p < 1\%$ (χ^2)

In all, only three items on both forms of the check-list show sex differences. The first favours the girls; statement 15 on the choosers check-list. Girls intending to take physics are more likely to express a determination to succeed in a difficult subject than are the boys. This is consistent with the earlier finding that it is the boys who are more likely to choose the subject because it is easier.

The other two sex differences appear in the rejectors' check-list. Girls are more likely to reject the subject because of difficulty, while it is the boys who are more concerned with deficiencies in practical work.

7.7.5. CORRELATES WITH ATTAINMENT

Attainment in physics measured by the G.C.E. O-level examination (using a six point scale of A=6, B=5, etc.) was used as the criterion variable in a series of multiple regression analyses (Section 2.9) to determine which of the sixteen statements had the strongest association with academic success. Table 7.7.7 summarises the results.

TABLE 7.7.7. THE ACADEMIC ATTAINMENT CRITERION

Pupil sub-group	Mean O-level 'score'	Statements most strongly associated with attainment	Beta-weight
Boy choosers (N = 207)	4.33	7. The O-level course was easy	0.20
		13. You are attracted by the type of exams in A-level physics	-0.17
		3. University and/or career requirements	0.16
Girl choosers (N = 43)	4.93	2. You have a better grade in physics than in most other subjects	0.48
Boy rejectors (N = 100)	3.23	2. Your physics grade is lower than the grade in most other subjects	-0.36
		1. You have a low O-level physics grade	-0.24
Girl rejectors (N = 77)	3.79	1. You have a low O-level physics grade	-0.28
		9. There was not enough student experimental work in the O-level course	-0.25
		4. It would not have been a main subject and it could not be fitted into the school/college timetable	-0.20

All beta-weights are significantly different from zero at the 5% level

The inferences to be drawn from the table are

a) high achieving boy choosers are likely to select A-level physics for career reasons and because the subject at O-level was easy (a perception of the type of A-level exam, is irrelevant);

b) high achieving girl choosers are likely tc select A-level physics because they anticipate that they will do well in the O-level exams in this subject;

c) low achieving boy rejectors are likely to reject A-level physics because of the likelihood of poor attainment in the physics exam, which is not unsurprising but does give support to the use of beta-weights in this type of analysis (Section 2.9);

d) low achieving girl rejectors are likely to reject A-level physics because of their low attainment and the lack of experimental work in the O-level course: even if they had done well, physics could not have been fitted into their timetables.

7.7.6. CONCLUDING REMARKS

In so far as the check-lists used in this research are able to present a comprehensive range of possible reasons for either choosing or rejecting A-level physics at the sixth-form choice stage, it can be concluded that, for the boys and girls of the sample used, it is primarily for career purposes that A-level physics is studied. This confirms the earlier findings of a number of research studies both in the U.K. and the U.S.A. (Section 2.7). Subsidiary reasons for the sample as a whole but, for a minority of students, major reasons even superior to any career requirement, are (i) a high O-level physics attainment, (ii) an interesting O-level course, (iii) an 'application' of mathematics and (iv) a general education in science.

Physics at A-level is rejected mainly because of the perceived difficulty of the O-level course. Although this is an important reason for boys, it is an even more important one for girls. Other slightly less important reasons for the majority are (i) an uninteresting O-level course and (ii) anticipated poor performance in the O-level physics examination. The subsidiary 'career' reason tends to be given more often by boys. Boys, also, are likely to feel that the mathematical nature of physics, and a lack of experimental work in the O-level course, are in themselves valid reasons for rejecting the subject.

The difficulty of physics (Section 2.2) has often been linked with the movement away from the physical sciences in the sixth-form (Ormerod with Duckworth, 1975; Duckworth and Entwistle, 1974b). Lessening the perceived difficulty of physics at the O-level stage might be expected from the findings of this research, to increase the proportion of pupils, and especially girls, going on to take A-level physics. This problem of subject difficulty and how it might be tackled has been considered in more detail in Section 7.6. The factor analyses of the responses show some revealing associations. For instance, evidence from Section 5.4.2 is that there is a tendency for O-level physics teachers to over emphasise the mathematical content of physics, which the pupils generally do not welcome. However, factor 6C 'mathematical ability', shows quite clearly that some of the pupils are choosing physics because of its mathematical approach, which satisfies their ability in this other academic subject. On the other hand, a mathematical approach to physics is a clear factor in its rejection and contributes to the common feeling amongst the rejectors that the subject and the teaching are generally unattractive with insufficient experimental work. The solution suggested in Section 7.4.4 , which was for a wider implementation of the varied/teaching-for-understanding approach in classrooms, is equally pertinent here. A greater emphasis on the medium of instruction, variability in presentation, including experimental work for the pupils, and the verbal rather than mathematical acquisition of concepts, can only improve the image of physics amongst those who are at present rejecting it.

Earlier, in Section 2.4 , evidence was considered that girls choosing to specialise in physics comprised a distinctive personality and attitudinal group. Section 7.5 contributes further evidence from the present research. Here, it is seen that girls choosing A-level physics are likely to be finding it more difficult than the boys but are more likely to express their determination to be successful. This suggests that these girls do possess the strong task-achievement motivation, which as Saraga has pointed out (Section 2.4) girls, in general, seem to lack. When this is allied to an analytic problem-solving ability, which these girls also seem to possess (Section 7.5.6), two of the three major handicaps which girls suffer in science education have been overcome. The third is the sex-role stereotyping in school. By choosing to study A-level physics, it is clear that the girls have overcome this handicap,too.

7.8. EXAMINATION PREPARATION, ATTAINMENT AND ATTITUDES

7.8.1. MATCH AND MIS-MATCH IN EXAMINATION PREPARATION

A 'match' between a preference or intrinsic worth rating on the 7-item examination preparation check-list (table 5.8.1 , scale A) and the corresponding degree-of-use rating was defined as occurring when a pupil in responding to a certain item scored either 1 or 3 on both scales. Over the range of seven items this enabled a pupil to obtain a 'match' score of between 7, a perfectly matched examination preparation environment, and zero, a complete mis-match in provision.

Table 7.8.1 shows correlates between the match score and a selected range of personality, attitudinal and attainment variables, data on which had been collected earlier. In some instances, a full set of data on all variables was not available because of pupil absence when the appropriate questionnaires were administered.

It is clear that matched examination preparation is associated, for both boys and girls, with (i) high O-level physics attainment, (ii) good academic achievement motivation, and (iii) a generally matched classroom environment on a whole range of learning activities. For girls only, there are additional associations with (iv) good study methods, (v) subject enjoyment and commitment, (vi) the degree of varied, teaching-for-understanding that they experience and (viii) a highly interest-rated teaching style.

TABLE 7.8.1. CORRELATES WITH EXAMINATION PREPARATION 'MATCH'

Variable	Sample Description	Sample Size	Correlation between 'match' and variable
1. O-level physics attainment	Boys	204	0.19**
	Girls	82	0.22*
2. Number of O-level passes	Boys	204	0.14*
	Girls	82	-0.29**
3. Study methods	Boys	175	0.07
	Girls	76	0.24*
4. Academic achievement motivation	Boys	175	0.27**
	Girls	76	0.27*
5. Physics subject 'slog'	Boys	175	-0.09
	Girls	76	-0.09
6. Physics subject enjoyment and commitment	Boys	175	0.14
	Girls	76	0.24*
7. Classroom physics teaching match	Boys	175	0.16*
	Girls	76	0.37**
8. Varied, teaching-for-understanding style (used)	Boys	175	0.03
	Girls	76	0.27*
9. Interesting teaching style	Boys	175	0.05
	Girls	76	0.25*

** $p < 1\%$; * $p < 5\%$

Subject 'slog' (i.e. difficulty and overloaded content) has no association with matched preparation.

Overall, it can be said that the more successful pupils show the better examination preparation match, but that the most able girls (as judged by the criterion of number of O-level passes) tend to be less satisfied with this aspect of their physics lessons.

7.8.2. PATTERNS IN REVISION NEEDS

Table 7.8.2. shows a correlation matrix for the preference items. Boys and girls results are reported separately.

TABLE 7.8.2. INTER-CORRELATION BETWEEN PREFERENCE ITEMS

Item	1	2	3	4	5	6	7
1. We had regular practice in answering O-level examination questions		17*	15*	18*	03	12	-01
2. A revision plan was followed by the class in the time before the examination	33**		-08	04	-02	07	10
3. Examination revision was done by using the student's own notes on the course	-02	16		04	03	15*	05
4. The topics covered in the O-level course were thoroughly treated	45**	41**	07		30**	29**	-27**
5. The O-level syllabus was completely covered	12	23*	-09	27*		22**	-14*
6. All O-level topics covered in the course were revised for the examination	29**	46**	16	44**	32**		-07
7. The topics covered in the O-level course were restricted to those thought essential for an examination pass	10	-06	-04	-10	08	-15	

Decimal points are omitted
** $p < 1\%$; * $p < 5\%$
Coefficients for boys (N=204) above the diagonal; girls (N=82) below.

The correlation matrix shows clearly that boys recognise the need for a broad and thorough syllabus coverage as expressed by items 4, 5, 6 and 7 (reversed). To the girls, syllabus coverage as defined by items 4, 5 and 6 is an aspect of a more expansive revision factor, which also specifies revision techniques, namely practising answers to questions and following a revision plan (items 1 and 2).

The failure of item 3 to show up strongly in association with the other revision items, although it does have a positive but weak influence for boys, suggests that many pupils are unsure why they have to make their own notes on course material.

7.8.3. ATTAINMENT AND ENJOYMENT CORRELATES

The relative strengths of associations between the item responses and O-level physics attainment and enjoyment were investigated by performing multiple regression analyses. The independent 'predictor' variables were (i) in the first analysis, the seven items in their preference or intrinsic worth mode (scale A), and (ii) in the second analysis, the seven items in their degree-of-use mode (scale B).

Physics attainment was measured on the usual six-point scale corresopnding to the G.C.E. O-level grade. Grade A was scored '6', grade B was scored '5', and so on. Enjoyment scores were obtained from the modified Science Attitude Questionnaire (Section 5.2).

Both attainment and enjoyment analyses were found to be sex dependent. The statements which made significant contributions at the 5% level to the relevant regression equations appear in tables 7.8.3 to 7.8.6.

TABLE 7.8.3. CORRELATES WITH ATTAINMENT: PREFERENCE ITEMS

Sample sub-group	Statement	Beta-Weight	Simple correlation	Multiple correlation, all items
Boys (N=204)	3. Examination revision was done by using the student's own notes on the course	0.15	0.17	0.28
Girls (N=82)	3. Examination revision was done by using the student's own notes on the course	0.19*	0.20	0.23

A single asterisk indicates that although the beta-weight fails to reach a significant level in the full regression equation, it is the largest.

TABLE 7.8.4. CORRELATES WITH ATTAINMENT: DEGREE OF USE ITEMS

Sample sub-group	Statement	Beta-weight	Simple correlation	Multiple correlation, all items
Boys (N=204)	1. We had regular practice in answering O-level examination questions	0.15	0.21	
	6. All O-level topics covered in the course were revised for the examination	0.14	0.20	0.31 (0.27)
Girls (N=82)	2. A revision plan was followed by the class in the time before the examination	0.16*	0.23	0.34

A single asterisk indicates that although the beta-weight fails to reach a significant level in the full equation, it is the largest. The multiple correlation in brackets expresses the association between attainment and a regression value calculated from just the two variables shown.

Pooling boys' and girls' responses to the preference items gives an overall multiple correlation of just 0.26 with attainment. Item 3 is the only item to make a significant contribution when the regression equation is constructed.

It is arguable, but a major reason for the careful instruction of pupils in lesson record keeping is to make effective examination preparation possible. Table 7.8.3 indicates that pupils who subscribe to this view are most likely to be found amongst those getting the best grades.

This finding is not as significant as it would be if the 'degree-of-use' form of item 3 had appeared in this context. Indeed, as table 7.8.4 shows, the actual classroom practices which are associated with attainment do not include item 3 at all. The best O-level physics grades are gained, in the case of boys, by pupils who have had regular practice in answering examination questions and whose revision covered all the topics previously taught in the course.

The analysis with the degree-of-use items for the girls is not so clear cut. The evidence from table 7.8.4 is that the higher achieving girls are more likely to be following a revision plan or scheme before the examination (this item also has the highest simple correlation with attainment).

TABLE 7.8.5. CORRELATES WITH ENJOYMENT: PREFERENCE ITEMS

Sample sub-group	Statement	Beta-weight	Simple correlation	Multiple correlation, all items
Boys (N=184)	7. The topics covered in the O-level course were restricted to those thought essential for an examination pass	0.14	0.13	0.23
Girls (N=81)	4. The topics covered in the O-level course were thoroughly treated	0.21	0.16	0.30

Simple correlations fail to reach significance at the 5% level. Neither beta-weight is significant at the 5% level, but they do have the highest values in their respective regression equations.

TABLE 7.8.6. CORRELATES WITH ENJOYMENT: DEGREE OF USE ITEMS

Sample Sub-group	Statement	Beta-weight	Simple correlation	Multiple correlation, all items
Boys (N=184)	2. A revision plan was followed by the class in the time before the examination	0.17	0.21	
	6. All O-level topics covered in the course were revised for the examination	0.17	0.19	0.30 (0.26)
Girls (N=81)	4. The topics covered in the O-level course were thoroughly treated	0.32	0.25	
	5. The O-level syllabus was completely covered	-0.24 (two variable equation)	-0.16	(0.35)

The multiple correlation in brackets expresses the association between enjoyment score and a regression value calculated from just the two variables shown.

Table 7.8.5. shows very weak relationships between preference item scores and enjoyment of physics lessons. Meaningful interpretation is not really possible in this instance. However, a sharper analysis is given where 'degree-of-use' items are used to 'predict' enjoyment (table 7.8.6). Boys who show the strongest enjoyment are likely to be following a revision plan which allows all the topics covered to be revised. On the other hand, girls with high enjoyment scores are to be found in classes where the O-level topics are thoroughly treated but where complete syllabus coverage is unlikely.

7.8.4. AN ASSOCIATION WITH A PREFERRED TEACHING METHOD

Section 5.4 identified a relatively strong teaching/learning dimension which is associated with desirable achievement and attitudinal outcomes. This varied/teaching-for-understanding approach emphasises organised, varied learning experiences to establish a hierarchy of linked concepts using simple verbal (rather than mathematical), experimental and audio-visual techniques. A more extensive desirable learning profile has also been identified in Sections 5.4 and 7.4 and the pupils' perceptions of their actual classroom environment has been matched with their individual learning profiles.

Table 7.8.7 shows the correlations between the scores on the examination preparation items and the wider classroom environment scales.

In so far as the varied/teaching-for-understanding scale measures an optimum physics teaching approach, it is seen that boys would add 'regular question practice' and girls would add 'drawing up a revision plan' and 'revision from own notes' to the overall ideal profile of classroom activities.

Sex differences also exist when real experiences are reported (degree of use forms in table 7.8.7). Although the varied/teaching-for-understanding style is accompanied by a thorough treatment of O-level topics, generally, boys report that this teaching method involves the use of a class revision plan, while the girls' experience is that it is a comprehensive revision of topics which is associated with this desirable teaching approach.

The analysis in Section 7.4.2 has shown that

TABLE 7.8.7. CORRELATION BETWEEN EXAMINATION PREPARATION AND OTHER LEARNING ENVIRONMENT VARIABLES

Statement describing examination preparation method	Correlation between statement and 'varied/ teaching-for-understanding' scores				Correlation between degree-of-use form of examination preparation statement and classroom environment match	
	Preference forms		Degree-of-use forms			
	Boys (N=184)	Girls (N=81)	Boys (N=184)	Girls (N=81)	Boys (N=184)	Girls (N=81)
1. We had regular practice in answering O-level examination questions	0.21**	0.16	0.08	0.05	0.10	-0.03
2. A revision plan was followed by the class in the time before the examination	0.06	0.31**	0.18*	0.03	0.24**	0.08
3. Examination revision was done by using the students own notes on the course	0.04	0.33**	0.00	-0.04	-0.02	-0.04
4. The topics covered in the O-level course were thoroughly treated	0.10	0.17	0.15*	0.33**	0.07	0.37**
5. The O-level syllabus was completely covered	0.07	-0.08	0.09	0.00	-0.04	-0.06
6. All O-level topics covered in the course were revised for the examination	0.02	0.19	0.05	0.27*	0.07	0.26*
7. The topics covered in the O-level course were restricted to those thought essential for an examination pass	0.05	-0.08	0.04	-0.04	0.09	-0.05

** $p < 1\%$; * $p < 5\%$

classroom environment match is highly correlated with actual experience of the varied/teaching-for-understanding style. This explains the similarity of the pattern of correlation coefficients in the second and third sections of table 7.8.7. In other words, in a matched physics classroom environment in the wider sense (Section 7.4), boys are likely to be working to a revision plan, while girls will be revising all their subject topics which will have been thoroughly treated in earlier lessons.

7.8.5. CONCLUDING REMARKS

The evidence from this Section is that there are real, although weak, associations between success and enjoyment in O-level physics and the nature of the examination preparation that the pupils experience. When several, separate techniques are shown to contribute to an overall successful outcome, it is prudent to recommend to the teacher, who wishes to establish a classroom climate which allows as many pupils as possible to maximise achievement and develop positive attitudes, that all the desirable techniques should be practised so that for some of the time, at least, the pupils will experience their particular environment match. This points to an optimum situation where the teacher

gives a thorough treatment to the course topics; revises all these topics before the examination according to a revision plan, and arranges for regular practice in answering examination questions.

With the exception of the question practice, the survey class teachers often failed to achieve this optimum style in a number of respects. A significant deficiency for both boys and girls is the lack of a revision plan. this suggests that if teachers were to play a positive role, at this level, in more closely directing the revision of their pupils, attainment benefits might occur and positive subject attitudes be enhanced.

Differential sex attitudes to examination preparation appear, with the girls preferring a more systematic approach. The girls' strategy emphasises a comprehensive revision of all the topics taught from their own notes within a revision plan. The girls with the better study methods get the better examination grades. The correlations for the girls in table 7.8.1 suggest that the teacher's ability to match examination preparation methods to the needs of the pupils is part of that sensitivity to the climate of the classroom which permits enjoyment of the subject to flourish. The boys, on the other hand, are more pragmatic seeing regular question practice as the key to success.

Earlier in Section 7.5.6 , a case has been made for a reduction in the content of O-level examination syllabuses, this is supported to some degree by the examination preparation check-list which reports that less than one-third of the pupils believe that they have covered the complete syllabus (Appendix 5.8.2).

7.9. CLUSTERS OF PHYSICS CLASSES

7.9.1. THE CLASS AS A UNIT OF ANALYSIS

In the Harvard Project Physics evaluation (Section 2.6), class mean scores were investigated as well as individual pupil scores. As Anderson and Walberg (1968) point out, correlations between variables for groups may differ in both sign and magnitude from those for individuals. Anderson and Walberg used the multiple correlation technique to 'predict' class achievement scores but they were unable to find any effective relationships. Walberg (1969b) used simple correlations to show that classes rated as 'satisfying' gained most on 'interest' scales. He was also able to show that the 'predictors' for achievement and attitudes were practically independent.

The present research permits class mean scores to be calculated on all the relevant fifth-form and teacher variables appearing in table 5.1.1. These variables are shown again in table 7.9.1, accompanied where appropriate with a code name to allow the analyses and tables to be displayed concisely in this Section.

It proved impossible to acquire teacher attitude data from one of the classes, so mean scores were calculated for 36 classes only and 536 pupils.

Some classes contained a significant number of pupils who subsequently sat the C.S.E. rather than G.C.E. examination. As all the pupils in a class are responsible for the climate which develops and within which class members learn, no matter whether the individual pupil's final assessment is by the C.S.E. or G.C.E., it was felt that no pupil should be excluded from the analysis and that, for the purposes of this class mean investigation, a highly successful cognitive outcome could be measured just as well by a C.S.E. grade 1 as by a G.C.E. O-level grade A. The achievement variable is thus a measure of O-level or C.S.E. performance for this analysis.

7.9.2. THE INITIAL MULTIPLE REGRESSION ANALYSIS

A multiple regression analysis on class mean scores was performed using as the criterion variable (a) physics attainment and (b) identification with physics.

TABLE 7.9.1. VARIABLES USED IN THE CLASS MEAN SCORES ANALYSIS

Attitude area	Variable	Code name
Classroom outcomes	43. O-level physics grade*	PERFORM
	5. Physics identification	PHYSID
Characteristics brought by pupils into the physics classroom	7. Study habits	STUDYHAB
	8. Motivation	MOT
	12. Extraversion	EXTRAV
	13. Neuroticism	NEUROT
Characteristics acquired within the physics classroom	3. Learning by experiment	LBE
	6. Interesting teaching style	ITS
	10. Study habits in physics	PHYSHAB
	11. Motivation in physics	PHYSMOT
	16. Varied/teaching-for-understanding (experienced)	VARUND (E)
	18. Classroom match	MATCH
	20. Physics 'slog'	SLOG
	41. O-level physics exam.motivation**	IMPORT
Teachers' attitudes	47. Processes of science	TA1
	48. Competent, exam-oriented	TA2
	49. Pupil oriented	TA3
	50. Interest-in-science	TA4
	51. Learning theory	TA5
	52. Planned, experimental lab.	TA6
	53. Disciplined, pupil relations	TA7

* Or C.S.E. physics grade ** Or C.S.E. Physics exam. motivation

a) Physics attainment

The variables making significant contributions in variance (at the 5% level) to the regression equation appear in table 7.9.2. The beta-weights measure the strength of the association between the variable and the criterion. (Section 2.9).

TABLE 7.9.2. VARIABLES ASSOCIATED WITH ATTAINMENT

Variable	Beta-weight
VARUND (E)	1.00
TA5	0.84
MOT	0.70
NEUROT	0.55

In all, twenty variables were present in the prediction equation to give an overall multiple correlation between the variables and the attainment criterion of 0.81. Using just the four predictor variables of table 7.9.2 , a multiple correlation of 0.51 is obtained. Table 7.9.3 shows the relative contributions of the variables in this case.

TABLE 7.9.3. VARIABLE WEIGHTINGS IN THE RESTRICTED ANALYSIS

Variable	Beta-weight
MOT	0.39
NEUROT	0.29
VARUND(E)	0.18
TA5	0.03

In so far as it is valid to use just one linear predictive equation for all the classes in the analysis, it can be concluded that high attainment in physics is associated with classrooms where

i) the pupils are well motivated to school learning, generally;

ii) the pupils are of an anxious disposition;

iii) the teaching is oriented towards the varied/teaching for understanding style, and

iv) the teacher believes that teaching is most effective when based on a theory of learning.

b) <u>Identification with physics</u>

Physics identification was taken as the measure of the affective outcome rather than physics enjoyment because of strong associations between enjoyment, problem-solving and commitment to physics (Section 5.2.5).'Identification' is the composite measure of these three sub-scales and with learning-by-experiment concisely describes subject attitudes.

Only one variable, examination motivation, makes a significant contribution at the 5% level to the regression equation which predicts enjoyment and identification with physics. However, if the equation is built up in steps, five variables in all contribute significantly to the restricted equation. Table 7.9.4 shows the relative weightings of these variables.

TABLE 7.9.4. VARIABLES ASSOCIATED WITH STRONG ATTITUDES TOWARDS PHYSICS

Variable	Beta-weight
IMPORT	0.55
EXTRAV	-0.39
ITS	0.29
STUDYHAB	-0.27
PHYSMOT	0.12

The multiple correlation between the criterion variable and the value predicted by the regression equation is 0.90. Thus, 81% of the variation in physics attitude scores can be explained by variation in the variables of table 7.9.4.

In general terms, the classes that show the greatest identification with physics and find the subject most enjoyable:

i) rate personal success in the external examination highly;

ii) find the style of the physics teacher interesting in itself;

iii) tend to be introverted;

iv) tend to have rather poor study habits in school subjects, generally, but

v) are well motivated towards physics.

7.9.3. AREAS OF DIFFERENCE BETWEEN CLASSES

A factor analysis of all the variables showed that five factors had eigenvalues greater than unity, accounting for 69% of the total variance. Both orthogonal and oblique rotations of the factor axes were investigated. The factor structure correlation matrix for the latter appears in Appendix 7.9.1. The variables most strongly associated with each of the five factors are listed in table 7.9.5.

TABLE 7.9.5. FACTORS IN THE CLASS VARIABLE SCORES

Factor	Most strongly associated variables	
1 Well motivated, successful introverted classes	PHYSHAB MOT PHYSMOT EXTRAV	(0.81) (0.79) (0.77) (-0.75)
2 Desirable teaching profile (teacher rating)	TA3 TA5 TA1 TA6	(0.88) (0.85) (0.77) (0.66)
3 Desirable teaching profile (pupil rating)	VARUND (E) ITS MATCH PHYSID	(0.86) (0.84) (0.78) (0.56)
4 Non-nonsense exam. teaching	TA7 TA2	(0.79) (0.49)
5 Anxious classes who like learning by experiment	NEUROT LBE	(0.51) (0.42)

The figures in brackets give the correlation between the variable and the factor score.

The strongest factor inter-correlation was between factors 1 and 3 but with the small sample size just failed to reach signficance at the 5% level.

7.9.4. CLUSTERING THE DATA

Standard scores were calculated for 19 of the 21 variables, omitting the attainment and physics identification variables. A cluster analysis was then performed on the 19 variables using the P.M.M.D. program developed by Youngman (1975).

Six clusters of the 36 classes were obtained. The mean scores on each variable appear in table 7.9.6. The composition of these clusters was found to be independent of the order of the data input.

TABLE 7.9.6. CLUSTER MEAN SCORES

Variable	Cluster A (N = 10)	B (N = 9)	C (N = 5)	D (N = 5)	E (N = 3)	F (N = 4)
TA1	47.90	50.78	57.00*	47.20	33.00**	55.00
TA2	30.10	29.89	36.00	25.60	28.00	29.25
TA3	31.90	31.00	42.20**	31.20	21.33**	35.50
TA4	33.80	34.89	40.00	34.40	36.00	41.75
TA5	32.30	30.78	39.80**	28.80	23.67**	35.00
TA6	19.30	18.44	20.80	17.80	12.00**	21.25
TA7	42.70*	48.78	51.20	46.40	41.33	49.25
IMPORT	3.19	2.97	2.81	3.12	3.39	3.50
ITS	3.17	3.31	2.63	3.11	2.88	3.75
EXTRAV	12.32	13.28	13.98	13.88	12.92	10.97
NEUROT	10.91	9.74	10.62	13.03*	10.85	10.78
PERFORM	3.94	3.55	3.30	3.62	4.01	4.38
PHYSI	65.08	64.29	57.41	62.81	66.04	73.16*
LBE	20.92*	22.16	21.33	23.41	21.94	24.03
SLOG	4.44	3.94	4.60	5.07*	4.15	4.00
STUDYHAB	5.88	4.78	4.50	4.89	4.84	6.22
MOT	11.17**	9.98	9.66	9.67	10.60	11.66*
PHYSHAB	5.77	5.36	4.15*	4.93	5.30	6.56
PHYSMOT	11.63	10.96	8.98**	10.07	11.53	11.91
VARUND (E)	21.92	23.56	19.36	22.17	20.58	24.46
MATCH	9.60	10.41	8.82	9.44	8.67	11.78

**p < 1%; *p < 5% (between cluster mean and rest of sample)

TABLE 7.9.7. PREDICTING CLASS ATTAINMENT AND ATTITUDES

Cluster	N	Correlates with attainment: Variable	r	β	physics identification: Variable	r	β
A	10	TA2	0.87	0.75	IMPORT	0.84	0.74
		IMPORT	-0.62	-0.36	NEUROT	-0.57	-0.37
			multiple r	0.94		multiple r	0.91
B	9	TA4	0.62	-	PHYSMOT	0.66	0.59
					TA3	-0.58	-0.49
						multiple r	0.82
C	5	IMPORT	-0.80	-0.80	TA6	0.92	0.67
		TA2	-0.75	-	ITS	0.85	0.31
			multiple r	0.80		multiple r	0.94
D	5	IMPORT	0.99	-	PHYSMOT	0.93	0.87
					TA4	0.80	0.07
						multiple r	0.93
E	3	SLOG	1.00	-	STUDYHAB	1.00	-
		VARUND (E)	1.00	-	MOT	1.00	-
F	4	PHYSHAB	0.95	-	NEUROT	0.97	0.74
					TA3	-0.91	-0.27
						multiple r	0.98

While exploring the differences between clusters, it is possible to check how the outcome measures of attainment and physics identification/enjoyment are 'predicted' by the survey variables within the clusters. In Section 2.9 , it was explained how multiple regression used in this way can improve the predictive power of an analysis but, here, the small numbers of classes in the clusters seriously limits the validity of this approach. To overcome this difficulty, simple correlations between all the variables and the two outcome measures were inspected for significance (at the 5% level) and then used as 'predictors'. Where more than one variable appeared, multiple regression was used tentatively to identify and discard any variable whose variance was largely explained by its association with the others. Thus, in table 7.9.7 , the appearance of a variable and the direction of its simple correlation (r) is of interest rather than the magnitude of the correlation and the beta-weight (β).

Type A classes. Highly motivated, book-learning classes

The distinguishing characteristics of the pupils in these classes are high general academic motivation and a relative dislike of learning-by-experiment. The teachers do not rate the need for disciplined, pupil relationships as highly as those in other groups. With highly motivated, book-learning pupils, it is possible that teachers of these classes do not feel it so important to maintain a strongly disciplined atmosphere.

In this type of class, attainment is best when the teacher orients his competent teaching most strongly towards the forthcoming examination. Emotionally stable pupils, keen to do well in the examination, show the strongest enjoyment and commitment to the subject, although the keenest do not do as well as they expect.

Type B classes. Teacher-centred, neutral classes

This class type shows no distinguishing features from the norm in terms of mean scores. Pupil and teacher attitudes are all average. Successful outcomes, though, are associated with teacher attitudes. Teachers who try to cultivate an interest-in-science through understanding physics achieve the better examination results: if they are strong believers in pupil-oriented teaching, their classes find the subject less attractive.

If teacher attitudes are transferred through their classroom behaviour to their pupils, teachers who aim to teach for understanding by keeping firm control of the learning environment are seen to be most successful with this type of class.

Type C classes. Well intentioned, mis-match classes

Teachers in these classes are keen to emphasise the processes of science in their teaching, which should be pupil-centred and learning theory based. Despite these teacher attitudes, the pupils tend to rate the teaching style uninteresting, low on the varied/teaching-for-understanding style and mis-matched with their needs.

Although these pupil ratings just fail to reach statistical significance, it is noticeable that the differences are all in the same direction, towards an unhappiness with the type of teaching they experience.

The classes have very poor study habits and motivation scores in physics. Attainment is the poorest of the groups but not significantly so. The same is true of enjoyment and commitment to physics.

In this group, the worst attainment is shown by classes which contain the pupils who are keenest to do well in the examination and who are taught by teachers who try to teach competently towards passing. Hypothetically, the actual classroom environment and teaching methods could be conspiring to frustrate the intentions of the teacher and some of the more diligent pupils.

Classes which show the greatest attitudinal affinity towards physics are taught by teachers who rate learning in a planned, experimental laboratory highly and whose style interests the pupils.

Type D classes. Anxious, high-drive-for-success classes

This group of classes contains a high proportion of girls. Two classes are all-girls: the other three are mixed. Physics is found difficult. The pupils display high anxiety scores. None of the teacher attitude scores differ significantly from the norm defined by the rest of the survey sample.

The drive to succeed in physics has the strongest bearing on classroom outcomes. Attitudes are enhanced in classes where the teacher rates highly teaching for understanding through interest in science.

Type E. Expository pragmatic teaching of neutral science

Teacher characteristics here are strongly conservative. Very low ratings are given to the desirability of (a)teaching the processes of science, (b) orienting the lessons to satisfy the needs of the pupils, (c) employing a theory for learning, and (d) teaching by the planned experimental method.

There are no significant differences on the pupils' scales, although scores are below average on the ratings of varied/teaching-for-understanding provision, classroom environment match and interesting teaching style. However, classroom outcomes are above average, although not significantly so.

Interpretation of the correlation coefficients in table 7.9.7 is hazardous with so few classes, but attainment appears to depend upon the provision of the varied/ teaching-for-understanding method while subject attitudes reflect general motivation and study behaviour.

Type F. Optimum outcome classes

This group of four classes show the most desirable classrooms outcomes of all. Enjoyment and identification with physics is superior statistically to the other groups. But for the small size of this cluster, the attainment superiority would also reach the significant level. Motivation to academic studies is higher than in any of the other groups.

A whole range of pupil variables show the highest ratings, particularly those referring to learning-by-experiment, the provision of varied/teaching-for-understanding, a matched classroom environment and an interesting teaching style.

None of the teacher variables show significant differences from the sample 'norm', but the highest cluster ratings are shown on interest-in-science teaching, planned experimental laboratory provision and the need for disciplined pupil relationships.

In classes such as these, where the outcomes are so satisfactory, it seems parsimonious to draw attention to the relative influence of some variables rather than others. However, within the limits of the correlation analysis, it does seem that anxious pupils acquire particularly favourable attitudes in these classes, especially when taught by a teacher who seeks to retain a major control of the pupils' learning and does not expect too much pupil initiative. The best grades in the examination are obtained by those classes who have the most systematic approach to studying physics.

7.9.5. DISCRIMINATING BETWEEN THE CLUSTERS

To find the groups of variables which best distinguished the clusters from one another, a discriminant function analysis was run on the six clusters using the P.M.M.D. program (Section 2.9). Discrimination was possible in terms of five separate functions. The discriminant functions are described by means of inter-correlations between the functions and the variables in Appendix 7.9.2. The meanings of the functions are summarised in table 7.9.8.

The strongest discrimination is shown by two functions (1 and 2) which are essentially measures of teacher attitudes. When scores are computed on each function scale for every class, the plot of figure 7.9.1 results. Plots of other pairs of functions do not give such a clear structure to the cluster pattern, although these discriminating functions are arguably as interesting For instance, the relationship between classes taught by 'model science teachers' and classes with high mean scores on the pupil variables (functions 3 and 4) is of some importance. Figures 7.9.2 and 7.9.3 illustrate attempts to clarify this relationship. Just three clusters maintain their identity each time:

1. Cluster F - optimum outcome classes who, according to discriminant function 2, are taught by the 'model science teachers' of the survey.
2. Cluster B - teacher centred, neutral classes, where there is less motivation on the part of the pupils than in cluster F and where the pupils are more extraverted. Pupils find the subject as easy and the classroom environment

TABLE 7.9.8.

THE VARIABLES WHICH DISCRIMINATE BETWEEN THE CLASSES

Discriminant function	Variable	Correlation with function score
1. Pupil/learning-theory mis-match	TA5	0.62
	TA3	0.55
	TA2	0.54
	LBE	-0.48
	VARUND(E)	-0.42
	ITS	-0.34
2. Model science teachers	TA6	0.70
	TA1	0.60
	TA3	0.57
	TA5	0.49
3. Physics as an easy subject where the teaching matches the pupils' needs	SLOG	-0.70
	NEUROT	-0.56
	VARUND(E)	0.46
	MATCH	0.42
	ITS	0.40
4. Poorly motivated, low achieving extraverted classes	MOT	-0.82
	PHYSMOT	-0.74
	STUDYHAB	-0.62
	PHYSHAB	-0.60
	EXTRAV	0.59
	TA7	0.59
	PHYSID	0.52
	IMPORT	-0.49
	PERFORM	-0.43
5. Interesting science: learn it from experiments	TA4	0.73
	LBE	0.63

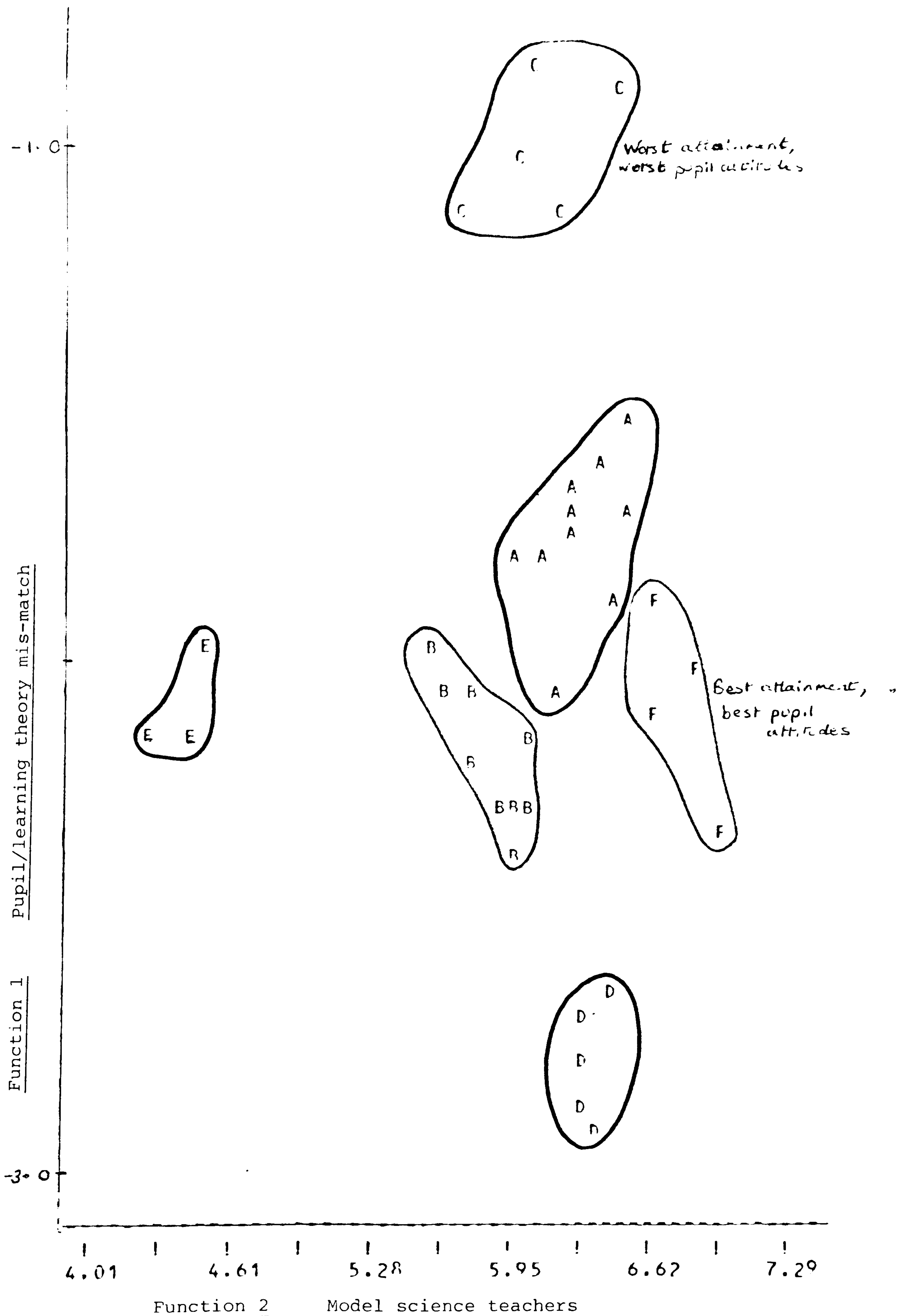
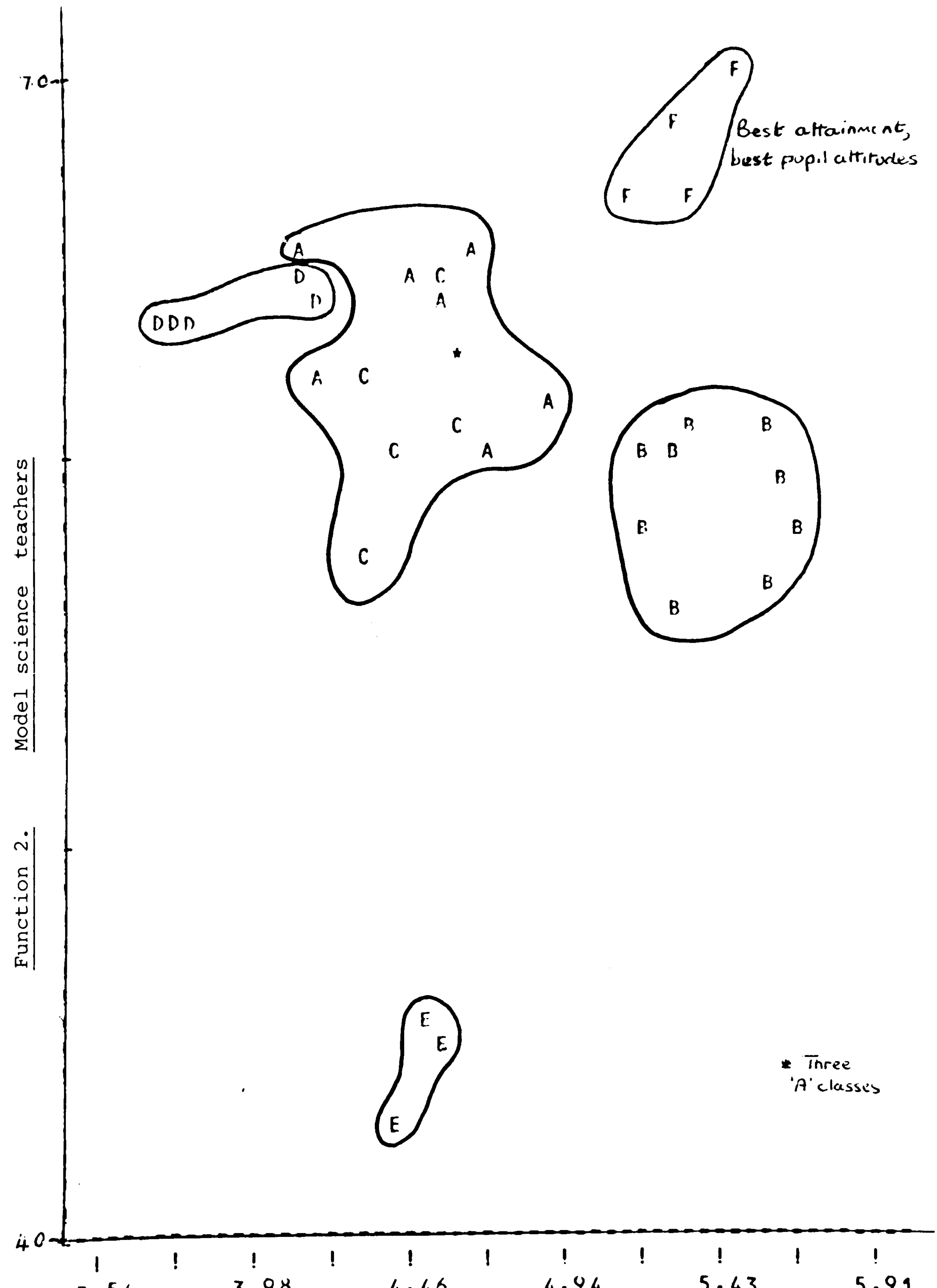


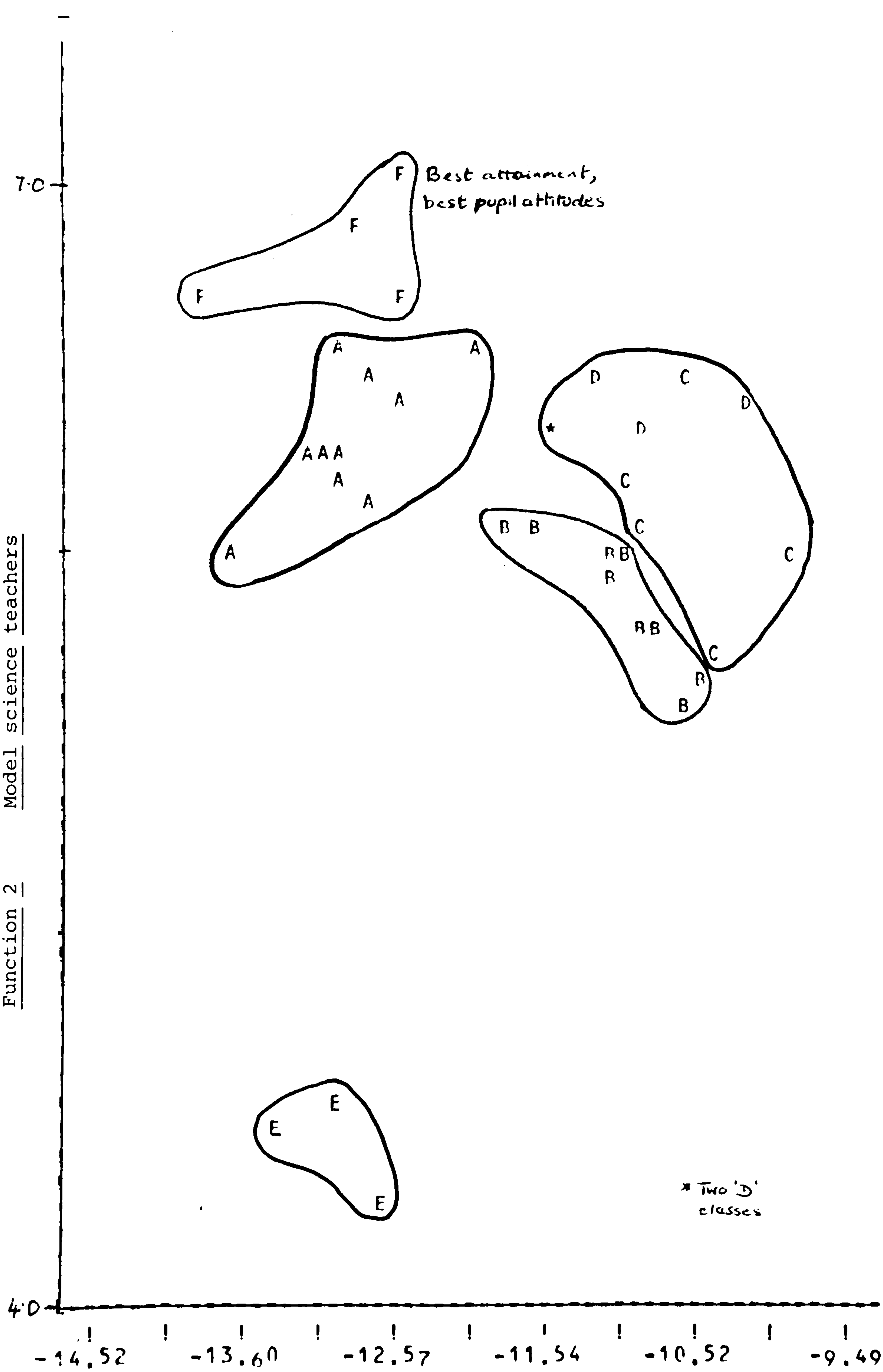
Figure 7.9.1. A plot of Function 1 against Function 2

Figure 7.9.2. A plot of function 2 against function 3



Function 3 Easy physics, teacher-pupil match

Figure 7.9.3. A plot of function 2 against function 4



Function 2 Model science teachers

Function 4. Poorly motivated, low achieving, extraVerted classes as matched to their needs as do those of cluster F classes. Teachers score lower on the 'model teacher' function.

3. Cluster E - pragmatic, neutral science classes, which are similar to cluster F classes on the personality and motivation variables, but where the teachers exhibit (in attitudinal terms) the weakest 'model' behaviour and the pupils find the subject more difficult in lower matched environments.

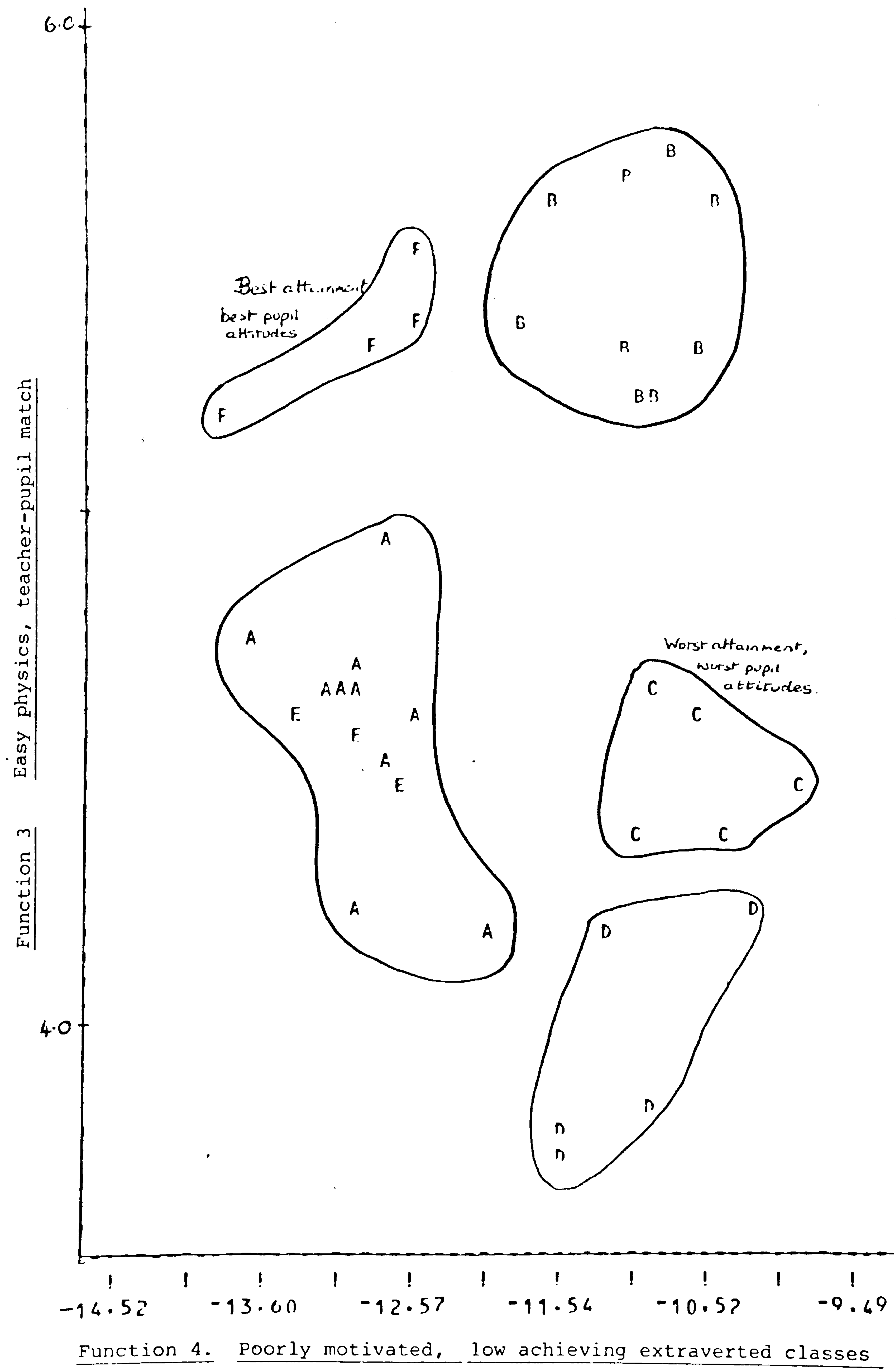
Figure 7.9.4 displays the clusters in terms of the two 'pupil functions'3 and 4.

7.9.6. CONCLUDING REMARKS

The findings reported in this Section make a notable contribution to the quest for a science of teaching science. The whole sample multiple regression shows the variables associated with the most desirable classroom outcomes. In so far as different sets of variables 'predict' achievement and attitudinal outcomes, confirmation of the findings of the H.P.P. evaluation project (Walberg, 1969b) has been obtained. However, as the cluster analysis shows, a typological structure of physics classes is possible, and although clear attitude patterns have been clouded somewhat by the small sizes of the clusters, there is evidence that prediction depends upon the nature of the classroom cluster.

Overall, classes with highly motivated, anxious

Figure 7.9.4. A plot of function 3 against function 4



pupils show the best attainment. What is more, the psychologically sound teacher and pupil feelings about the methodology to be adopted to achieve high attainment are also shown to be highly significant. An earlier survey of physics classrooms by the present author called for teachers to acquire a greater awareness of science learning theory to improve pupils' attitudes towards physics (Pell, 1977). Now, here is evidence (table 7.9.3) that teachers who demonstrate such an awareness are associated with high achieving classes. This relationship is not necessarily a causative one. It could be that teachers with the sounder educational background (higher scores on the learning-theory scale) either choose to teach, or are appointed to teach classes where the pupils are better motivated (and more able). However, the conclusion must be that nothing would be lost if physics teachers were to be persuaded that their method of communication and preparation might itself be a science, as well as the subject they teach.

The attractiveness of the teacher's methods positively influences subject attitudes (table 7.9.4). If a class comprises mainly introverted pupils, taught attractively and who, for the most part, have a strong drive to succeed in the external examination, then enjoyment and commitment to physics will be enhanced.

Classes that might be expected to display desirable outcomes in both cognitive and affective terms would comprise mainly, well motivated, anxious introverts, taught physics by an interesting, varied, linked-concept (understanding) method by a teacher who believes in the need to apply a learning theory. The cluster analysis and accompanying discriminatory plots show that the 'optimum outcome classes' of type F closely fit these statistical criteria. Table 7.9.9 summarises the discriminant plots in a convenient form.

TABLE 7.9.9. DISCRIMINATING BETWEEN CLASS CLUSTERS

		Discriminant Function			
		1	2	3	4
Class cluster	N	Pupil/learning theory mis-match	'Model' teachers	Easy physics, matched teaching	Poorly motivated low achieving extraverted pupils
A	10	0	+	-	-
B	9	0	0	++	+
C	5	++	+	-	++
D	5	--	+	--	+
E	3	0	--	-	-
F	4	0	++	++	-

Five point function scoring code from ++ (high) to -- (low)

Having identified class types it is now possible, at least in theory, to look for pupil stereotypes and to investigate their progress within the different forms of class (Section 7.11.15). The six class clusters themselves are unlikely to be exclusive. A larger sample could have yielded further stereotypes. However, the earlier research summarised in Sections 2.6 and 2.8 suggests that classes of type A, E and F, at least, are common among the physics class population at large. The factor analysis of table 7.9.5 shows that well motivated and successful classes tend to be introverted. With a much larger sample of classes, there is a hope that the characteristics of successful extraverted classes might appear, if this is indeed possible (Entwistle, 1973).

7.10 THREE BROAD POPULATION GROUPS

7.10.1. VARIABLES IN THE FIFTH-FORM PUPIL ANALYSIS

The fifth-form variables were selected from the survey variables of table 5.1.1. Classroom outcomes are measured by the G.C.E. or C.S.E. physics grade and the enjoyment/commitment to physics variable (physics 'identification'). To permit a concise presentation of the analyses in the tables, code names are used in this Section as follows:

TABLE 7.10.1. THE ANALYSIS VARIABLES

Attitude area		Variable	Code name
Classroom outcomes	43.	O-level physics grade*	PERFORM
	5.	Physics identification	PHYSID
Characteristics brought by pupils into the physics classroom	7.	Study habits	STUDYHAB
	8.	Motivation	MOT
	12.	Extraversion	EXTRAV
	13.	Neuroticism	NEUROT
	14.	Lie	LIE
Characteristics acquired within the physics classroom	3.	Learning-by-experiment	LBE
	6.	Interesting teaching style	ITS
	10.	Study habits in physics	PHYSHAB
	11.	Motivation in physics	PHYSMOT
	15.	Varied/teaching for understanding (preferred)	VARUND (P)
	16.	Varied/teaching for understanding (experienced)	VARUND (E)
	17.	Varied/teaching for understanding (mismatch)	VARUND (M)
	18.	Classroom match	MATCH
	19.	Physics satisfaction	SAT
	20.	Physics 'slog'	SLOG
	41.	O-level physics exam motivation**	IMPORT

* or C.S.E. physics grade
** or C.S.E. physics exam. motivation

The importance of the varied/teaching for understanding variable has been demonstrated in Sections 5.4 and 7.4 , where it was shown that most pupils experience less of this preferred style than they wish. To explore the amount of mis-match on this dimension of the classroom, the difference between scores on variables 15 and 16 was calculated to compute this specific mis-match measure.

Thus,

VARUND (M) = VARUND (P) - VARUND (E)

Mean scores on all the variables were subsequently calculated and compared for three population groups:

a) pupils leaving full-time education (Section 7.10.2),

b) pupils choosing A-level physics in the sixth-form or its equivalent (Section 7.10.3)

c) pupils rejecting A-level physics in the sixth-form or its equivalent (Section 7.10.4).

The intentions of the 547 pupils who had scores on all the variables, after completing fifth-form studies are expressed in table 7.10.2.

TABLE 7.10.2. FIFTH-FORMERS' INTENTIONS

Pupil group	N
Leaving full-time education	105
Choosing A-level physics	230
Continuing with full-time education rejecting A-level physics	212

7.10.2. PUPILS LEAVING FULL-TIME EDUCATION

The characteristics of the leavers are shown by the mean scores of table 7.10.3 , where a comparison is made with the scores of rest of the pupils.

As to be expected, the leavers have much the

TABLE 7.10.3. THE CHARACTERISTICS OF FIFTH-FORM LEAVERS

Variable	Mean scores (Standard deviation) Pupils leaving (N = 105)		Remaining pupils (N = 442)	
PERFORM	2.90	(1.43)	4.01	(1.37)**
PHYSID	58.95	(11.49)	65.28	(12.39)**
STUDYHAB	4.22	(2.45)	5.29	(2.15)**
MOT	8.71	(2.66)	10.79	(2.47)**
EXTRAV	14.52	(3.84)	12.72	(4.34)**
NEUROT	9.53	(4.22)	11.03	(4.09)**
LIE	2.73	(1.64)	2.83	(1.73)
LBE	22.11	(3.34)	21.75	(3.75)
ITS	3.12	(0.95)	3.13	(0.95)
PHYSHAB	4.45	(2.61)	5.52	(2.39)**
PHYSMOT	9.58	(3.59)	11.24	(3.07)**
VARUND(P)	25.18	(2.85)	25.90	(2.55)*
VARUND (E)	21.22	(3.93)	22.28	(3.68)**
VARUND (M)	3.96	(3.99)	3.62	(3.83)
MATCH	9.22	(3.64)	9.88	(3.46)
SAT	9.41	(2.14)	9.66	(2.10)
SLOG	4.45	(1.29)	4.32	(1.41)
IMPORT	2.79	(0.76)	3.19	(0.71)**
EXAM	66 G.C.E.	: 39 C.S.E.	388 G.C.E.	: 54 C.S.E.**
SEX	92 boys	: 13 girls	309 boys	: 133 girls**

**p < 1%, *p < 5% (t-test)
Variables EXAM and SEX are tested by χ^2

poorer overall attitudes and attainment. Classroom experiences are little different. Motivation and study approaches to academic subjects are significantly poorer. Strong personality differences exist: the leavers tend to be stable extraverts. Leavers are more likely to be boys and to have taken the C.S.E. examination.

The leavers' scores were subject to a principal components factor analysis. Six factors were found to account for 67% of the total variance. Both orthogonal and oblique solutions were investigated. Some intercorrelation between the factors suggested the use of the oblique method. Appendix 7.10.1 shows the detailed factor structure matrix of correlation coefficients. Table 7.10.4 summarises the analysis by showing the major variables for each factor.

TABLE 7.10.4. SUMMARY FACTOR STRUCTURE MATRIX FOR FIFTH-FORM LEAVERS

Variable	Correlation coefficient					
	Factor 1L	Factor 2L	Factor 3L	Factor 4L	Factor 5L	Factor 6L
PERFORM						-57
PHYSID						-51
STUDYHAB			81			
MOT	76					
EXTRAV			-39		30	
NEUROT					-73	
LIE			40			
LBE		-35				
ITS		62				
PHYSHAB			81			
PHYSMOT	89					
VARUND (P)				55		
VARUND (E)		58		67		
MATCH		76			35	
SAT						-48
SLOG						57
IMPORT	57					

Decimal points are omitted

Factor 1L is a <u>motivation factor</u>, measuring academic motivation, motivation in physics and the importance of success in the examination.

Factor 2L is a <u>teaching-style factor</u> measuring the generosity in provision of a varied, interesting teaching -for-understanding style in a classroom that matches the pupils needs. The contribution of learning-by-experiment is more easily appreciated if <u>low</u> scores on this factor are considered. In what would now be unattractive classrooms, with a low pupil preference match, the felt need for learning-by-experiment is much the stronger. There is a significant correlation at 0.24 between factors 1L and 2L.

The third factor is an indicator of <u>good study methods</u>, which tend to be displayed by introverts who are socially conforming (high lie score interpretation, Section 7.3.3.). Scores on this factor are found to correlate significantly at 0.24 with the motivation factor, indicating an association of desirable study habits with high motivation. Another significant association, at 0.22, is between factors 3L and 2L, implying that pupils receiving a generous provision of the matched, teaching-for-understanding method tend to have good study habits.

Factor 4L demonstrates a <u>varied/teaching-for-understanding continuum</u>. High scores indicate pupils who demand and get a comprehensive provision of this type of teaching. Such pupils are well motivated with good subject attitudes (table 7.10.3 suggests these pupils will be few in number). Low scores indicate pupils who are unconcerned about the need for varied/teaching-for-understanding; who are unlikely to get such teaching anyway, and who are likely to be poorly motivated with poor subject attitudes.

The personality attribute of stable extraversion is measured by factor 5L. Stable extraverts tend to find themselves in matched classroom environments. Factor 6L measures subject antipathy. More precisely, it is an indication of poor subject attitudes, subject difficulty and poor attainment. High scores on this factor correlate significantly and negatively at -0.43 with high motivation (factor 1L).

7.10.3. PUPILS CHOOSING A-LEVEL PHYSICS IN THE SIXTH-FORM

Mean scores for physics choosers and those rejecting physics in the sixth-form appear in table 7.10.5.

Potential A-level physics students display the superior attitudes (PHYSID, SAT) and attainment (PERFORM). Their motivation to succeed is stronger (IMPORT, PHYSMOT and MOT) although study methods, generally, do not differ. These students are likely to be taught in classrooms more sympathetic to their needs (MATCH) and where the teacher's style is more interesting. They prefer more of the varied/teaching-for-understanding method and generally experience more of this approach. The physics choosers, who are more stable and more introverted, find the subject easier.

Factor analysing the physics choosers' scores resulted in nine factors with eigenvalues of more than unity appearing. These factors accounted for 63% of the total variance of the scores. Inter-correlation between the nine factor scores was significant, so an oblique solution was obtained for inspection. Appendix 7.10.2 shows the detailed factor structure matrix of correlation coefficients. For this factorisation only, seven scores measuring the reasons offered by the pupils for studying A-level physics (Section 7.7.1) were added to help in interpretation. Table 7.10.6 summarises the analysis by showing the major variables for each factor.

TABLE 7.10.5. THE CHARACTERISTICS OF A-LEVEL CHOOSERS AND REJECTORS

	Mean scores (Standard deviation)			
Variable	Pupils choosing A-level physics (N = 230)		Pupils rejecting A-level physics in the 6th-form (N = 212)	
PERFORM	4.46	(1.21)	3.53	(1.37)**
PHYSID	71.34	(9.99)	58.70	(11.36)**
STUDYHAB	5.36	(2.07)	5.22	(2.23)
MOT	11.37	(2.19)	10.16	(2.61)**
EXTRAV	12.14	(4.19)	13.34	(4.42)**
NEUROT	10.60	(3.85)	11.49	(4.30)*
LIE	2.97	(1.62)	2.68	(1.82)
LBE	21.69	(3.67)	21.82	(3.85)
ITS	3.33	(0.88)	2.91	(0.97)**
PHYSHAB	6.03	(2.14)	4.96	(2.53)**
PHYSMOT	12.54	(1.93)	9.82	(3.43)**
VARUND (P)	26.32	(2.12)	25.45	(2.88)**
VARUND (E)	22.90	(3.62)	21.60	(3.63)**
VARUND (M)	3.42	(3.79)	3.85	(3.87)
MATCH	10.38	(3.54)	9.33	(3.29)**
SAT	10.59	(1.54)	8.66	(2.17)**
SLOG	3.82	(1.38)	4.87	(1.24)**
IMPORT	3.48	(0.65)	2.88	(0.66)**
EXAM	222 G.C.E. :	8 C.S.E.	166 G.C.E. :	46 C.S.E.**
SEX	187 boys :	43 girls	122 boys :	90 girls**

** $p < 1\%$; * $p < 5\%$ (t-test)

Variables EXAM and SEX are tested by χ^2

TABLE 7.10.6. SUMMARY FACTOR STRUCTURE MATRIX FOR A-LEVEL PHYSICS CHOOSERS

	Correlation coefficient								
Variable	Factor 1C	Factor 2C	Factor 3C	Factor 4C	Factor 5C	Factor 6C	Factor 7C	Factor 8C	Factor 9C
PERFORM				34	-31				
PHYSID							-57		
STUDYHAB	90								
MOT				96					
EXTRAV						77			
NEUROT									
LIE						-28			
LBE									51
ITS		41					-37		
PHYSHAB	81								
PHYSMOT				83					
VARUND (P)									
VARUND (E)		83							
MATCH		59							
SAT							-52		
SLOG			-31						
IMPORT					-51				
REASON 1C			88						
REASON 2C								54	
REASON 3C			30						
REASON 4C								37	
REASON 5C							-36		
REASON 6C			62						
REASON 7C					-30				-33

Decimal points are omitted

Factor 1C clearly measures study methods.

High scores on factor 2C indicates physics classrooms where there is a strong provision of the varied/ teaching-for-understanding approach, where a close match is achieved with the pupils learning preferences, and the teacher's style is interesting.

The easy nature of the course and subject is expressed by factor 3C. Reason 1C expresses the choice of A-level physics in terms of perceived easiness at both O- and A-level. Reason 3C envisages a good O-level performance in physics, while Reason 6C implies that the mathematical nature of the O-level course has made it easy.

Factor 4C is a motivation factor, showing some association with attainment.

When the directions of the correlations are reversed, factor 5C is a measure of extrinsic motivation. It is important to be successful for career reasons (reason 7C). There is an association with attainment.

Reversing the directions of the correlations for factor 6C reveals a dimension which measures introversion accompanied by a strong social code of behaviour (high LIE - Section 7.3.3).

Again, reversing the correlations for factor 7C, indicates a wide subject interest dimension. Both the course and teaching style excite the interest. Choice reason 5C measures intrinsic subject interest at O- and A-level.

The remaining two factors are less psychologically homogeneous.

Factor 8C measures just two choice reasons. Reason 2C expresses confidence in tackling a difficult subject, while reason 4C indicates that educational attractiveness and the implications of science are of consideration.

Factor 9C (correlations reversed) measures the dislike of learning-by-experiment by pupils who choose physics for career reasons.

Table 7.10.7 shows significant correlations between the factors.

TABLE 7.10.7. FACTOR INTER-CORRELATIONS : CHOOSING PHYSICS

Inter-correlation between factors	Correlation coefficient
1C and 4C	0.23
2C and 7C	-0.17
2C and 9C	0.14
3C and 4C	0.15
3C and 7C	-0.27
3C and 8C	0.13
4C and 5C	-0.25
4C and 7C	-0.19
5C and 6C	0.16
7C and 8C	-0.18

A correlation of 0.13 is significantly different from zero at the 5% level (N = 230)

The strongest inter-correlations between the factors show that

a) good study habits are associated with high motivation and attainment;

b) extrinsic and academic achievement motivation are positively related;

c) easiness is associated with subject interest, and

d) subject interest is positively related to a matched environment biased towards the varied/ teaching-for-understanding approach.

7.10.4. PUPILS REJECTING A-LEVEL PHYSICS IN THE SIXTH-FORM

Before factor analysing the scores of the physics rejectors, five scores from Section 7.7.2 were added as measures of the reasons for rejecting the subject. The analysis showed that seven factors with eigenvalues greater than unity could account for 60% of the total score variance. Some significant correlations between the factor scores suggested that an oblique rather than the orthogonal solution was to be preferred. Appendix 7.10.3 shows the detailed factor structure matrix of correlation coefficients. Table 7.10.8 summarises the analysis by showing the major variables for each factor.

Factor 1R measures negative attitudes towards physics and the unimportance of success in the examination.

Factor 2R, relating to classroom environment match with pupil expectation, is similar to the choice factor 2C.

Factor 3R, reversing the correlations, expresses a measurement of good study habits for introverted pupils with high LIE (conventional social behaviour) scores.

Rejection reasons make up factor 4R. These are (i) reason 1R - the uninteresting nature of a narrow subject taught unattractively with little experimental work; (ii) reason 3R - too mathematical a subject, and (iii) reason 4R - a difficult A-level course and final examination.

Factor 5R is a motivation factor, and like factor 5C shows some association with attainment.

Reason 5R, which with learning-by-experiment defines factor 6R, expresses rejection of physics because of career plans or timetabling difficulties. Thus, factor 6R is in some ways the complement of the choice factor 9C. Whereas pupils choosing physics for career purposes tend not to prefer learning-by-experiment, those rejecting physics for career reasons do tend to prefer this approach.

TABLE 7.10.8. SUMMARY FACTOR STRUCTURE MATRIX FOR A-LEVEL PHYSICS REJECTORS

Variable	Correlation coefficient						
	Factor 1R	Factor 2R	Factor 3R	Factor 4R	Factor 5R	Factor 6R	Factor 7R
PERFORM					(29)		-49
PHYSID	-62						
STUDYHAB			-96				
MOT					88		
EXTRAV			39				
NEUROT							37
LIE			-38				
LBE						64	
ITS		52					
PHYSHAB			-80				
PHYSMOT					79		
VARUND (P)		35					
VARUND (E)		77					
MATCH		69					
SAT	-47						
SLOG							39
IMPORT	-57						
REASON 1R				71			
REASON 2R							62
REASON 3R				47			
REASON 4R				31			
REASON 5R						33	

Decimal points are omitted

Factor 7R is the <u>subject difficulty</u> factor (the complement of 'easiness' factor 3C). Physics is rejected because of an anticipated low grade in a difficult subject (reason 2R) by pupils who are inclined to be anxious and worry over this difficulty. The direction of the attainment association confirms the pupils' fears of a poor grade.

Significant factor inter-correlations are shown in table 7.10.9.

TABLE 7.10.9. FACTOR INTER-CORRELATIONS : REJECTING PHYSICS

Inter-correlations between factors	Correlation efficient
1R and 2R	-0.21
2R and 3R	-0.26
2R and 4R	-0.21
2R and 5R	0.22
3R and 5R	-0.32
3R and 7R	0.41
4R and 5R	-0.15
5R and 7R	-0.33

A correlation of 0.14 is significantly different from zero at the 5% level (N = 212)

The strongest inter-correlations between the factors show that

a) pupils finding the subject difficult and rejecting it for this reason tend to be extraverted with poor study habits;

b) extraverted pupils with poor study habits tend to be in poorly matched classes with low provision of the varied/teaching-for-understanding approach;

c) introverted pupils with good study habits are likely to be well motivated, and

d) pupils giving 'uninteresting', 'too mathematical', and 'A-level difficulty' as rejection reasons tend to be in poorly matched classrooms with low provision of the varied/teaching-for-understanding approach.

7.10.5. CONCLUDING REMARKS

Factors common to each of the three pupil sub-groups are:

a) study habits,

b) motivation,

c) the provision or lack of varied, teaching-for-understanding in a classroom environment which matches the pupils' needs.

A fourth factor, subject enjoyment and interest, although defined by different variables for each pupil sub-group, is also recognisable. For pupils going on to A-level, subject difficulty is another strong factor.

Comparing mean scores on the four major areas which have been identified shows that the leavers, unsurprisingly, score low each time. Physics choosers have the better academic achievement motivation, which is a confirmation of Soh's finding (Section 2.5) with younger potential 'scientists' in the secondary school. General study habits, however, do not discriminate between potential A-level physics and other sixth-form students. A major finding is that physics choosers come from more compatible classrooms, where learning preferences are better matched and the varied/teaching-for-understanding method is more widely practised. Unlike academic achievement motivation, which is arguably more a function of the climate of the school (Brimer et al., 1978), classroom activities and approaches to learning are under the direct control of the teacher. Section 7.4 has shown how manipulating these classroom variables might improve subject attitudes. The same variables can also influence subject difficulty, (Section 7.5.6) and ultimately attainment, which could then lead to a more homogeneous population of potential sixth-formers who would find it less easy to decide against 'difficult' and 'disliked' physics.

7.11. PUPIL STEREOTYPES IN THE FIFTH-FORM

7.11.1. VARIABLES IN THE ANALYSIS

The fifth-form variables were introduced in table 5.1.1. Table 7.10.1 shows the continuous variables used in the multivariate analyses, together with the code names which appear in tables. To the variable set from table 7.10.1, the four dichotomous variables of sex, form of examination assessment, expressed intention to enter the sixth-form and expressed intention to study A-level physics were added (table 7.11.1).

TABLE 7.11.1. THE FOUR DICHOTOMOUS VARIABLES

Dichotomous variable	Scoring description		Code name
Sex	boys 0;	girls 1	SEX
Examination	G.C.E. 0;	C.S.E. 1	EXAM
Entering the sixth-form	No 0;	Yes 1	ALEVEL
Choosing A-level physics	No 0;	Yes 1	PHYSCHOICE

The continuous variables appear in table 7.10.1.

7.11.2. CLUSTERING THE DATA

In all, 22 variables described the characteristics of 547 pupils. As two of the variables, O-level (or C.S.E.) physics achievement and physics identification, were the two criteria measures of the outcomes of fifth-form physics education, they were excluded from the cluster analysis which was to attempt to identify pupil stereotypes. This was because any later regression or correlation test of 'prediction' would be required to act upon the variance in the criterion scores. Entering the latter into the cluster analysis would tend to reduce their variance within the cluster to a minimum and make 'prediction' unreliable.

Using Youngman's P.M.M.D. program (Section 2.9), a cluster analysis of the 20 variables resulted in the cluster fusion plot of Appendix 7.11.1. The sudden increases in the error distance or fusion coefficient suggests that seven cluster and possibly four cluster solutions should be inspected as establishing psychologically distinct pupil stereotype groupings. The stability of these solutions was demonstrated by repeating the analysis with a random re-arrangement of the data input order so that the program would start with a completely different membership for the initial fifteen clusters before the similarity testing begins. For a consistent solution, the same pupils should finish up in the same clusters after successive iterative procedures. Inspection showed that consistent seven and four cluster solutions were obtained with only minor shifts of pupils from one cluster to another.

The simpler, four-cluster solution is summarised in table 7.11.2 in terms of the major distinguishing characteristics of the pupils. Cluster mean scores appear in Appendix 7.11.2.

TABLE 7.11.2. THE FOUR CLUSTER SOLUTION

Group	Pupil Characteristics
A (N = 201)	A highly favourable image of physics. Mainly introverted boys, they nearly all (92%) intend to study the subject at A-level. Classroom physics teaching is likely to match the pupils needs, and comprises a high degree of the varied, teaching-for-understanding style. These pupils are well motivated and with good study habits, especially in physics. They record the highest physics attainment
B (N = 80)	This is the second group who choose A-level physics but, in this instance, such pupils are in the minority (35%, in all). Attitudes to physics are poor. The pupils have a poor perception of the physics classroom environment, which fails to meet their needs (for the varied, teaching-for-understanding approach). This group contains a higher proportion of girls than A.
C (N = 83)	These are poorly motivated, extraverted pupils who are likely to be taking C.S.E. physics (about 70% of the whole group). Attitudes towards physics are poor, as are study methods and motivation. The subject is rated very difficult. Attainment is low.
D (N = 183)	This is another low achieving group but comprises mostly G.C.E. pupils in well matched classes where varied, teaching-for-understanding is provided. Study habits and motivation are satisfactory, but the subject is found difficult.

Clusters A and C show the two extreme classroom outcomes. The most desirable attitudes and highest achievement are displayed by introverted boys with good study habits and motivation in a matched classroom environment which emphasises the varied, teaching-for-understanding approach. Extraversion, mis-match in the environment, poor study habits and motivation are characteristic of low achievers with poor attitudes.

The two intermediate clusters B and D differ mainly because the former are in highly mis-matched classes and the latter find the subject very difficult. Cluster B achievement is moderate, despite the dissatisfaction with the learning environment, and a proportion of pupils still intend to take A-level physics.

The dendrogram accompanying the cluster analysis output (Appendix 7.11.3) shows how the clusters are fused as the program proceeds. Clusters A and D show a sub-group structure, while clusters B and C have a relatively more robust statistical consistency. As the most refined cluster structure reliably permitted by the data was at the seven cluster level, the investigation was concentrated on this higher order solution.
Table 7.11.3 gives the standardised mean cluster scores.
Table 7.11.4 summarises the differences between the clusters. It will be noted that some of the members of clusters B and C in the four-cluster analysis are re-allocated to more similar groups in the higher order analysis.

TABLE 7.11.3. THE SEVEN CLUSTER SOLUTION

	Cluster mean scores (standardised)						
Variable	A_1	A_2	B	C	D_1	D_{2A}	D_{2B}
PERFORM	0.40**	0.52**	0.00	-0.76**	-0.52**	-0.33	0.13
PHYSID	0.38**	0.91**	-0.33*	-1.19**	-0.10	-0.43**	-0.09
STUDYHAB	-0.55**	0.67**	-0.17	-0.93**	-0.02	-0.29	0.76**
MOT	-0.11	0.79**	-0.10	-1.26**	-0.19	-0.26	0.41**
EXTRAV	-0.11	-0.38**	0.33	0.41*	0.31	0.39*	-0.54**
NEUROT	0.43**	-0.28*	-0.02	0.12	-0.60**	0.85**	-0.39*
LIE	-0.31	0.29*	-0.18	-0.29	0.12	-0.70**	0.82**
LBE	0.14	-0.12	0.01	0.28	-0.17	0.09	-0.14
ITS	0.33*	0.41**	-1.17**	-0.48**	0.43**	-0.24	0.23
PHYSHAB	-0.26	0.79**	-0.23	-1.36**	0.14	-0.35**	0.59**
PHYSMOT	0.25*	0.77**	-0.10	-1.74**	0.12	-0.25	0.17
VARUND (P)	0.14	0.24	0.44*	-0.91**	-0.12	-0.14	0.09
VARUND (E)	0.65**	0.30**	-1.43**	-0.74**	0.22	0.26	0.19
VARUND (M)	-0.54**	-0.13	1.69**	0.10	-0.29	-0.35*	-0.13
MATCH	0.40**	0.44**	-1.16**	-0.45**	0.21	-0.04	0.08
SAT	0.48**	0.67**	-0.44**	-1.09**	0.31	-0.44*	-0.15
SLOG	-0.29	-0.74**	0.12	0.67**	-0.14	0.52**	0.46**
IMPORT	0.51**	0.61**	-0.02	-1.00**	-0.17	-0.25	-0.31
EXAM	-0.30*	-0.36**	-0.04	1.42**	0.35*	-0.38*	-0.21
SEX	-0.05	-0.42**	0.27	-0.04	-0.47**	0.49**	0.47**
ALEVEL	0.47**	0.47**	0.05	-0.69**	-1.93**	0.47**	0.53**
PHYSCHOICE	1.05**	1.02**	-0.11	-0.82**	-0.85**	-0.83**	-0.51**

A single asterisk indicates that the cluster mean is significantly different from the mean of the remaining scores at the 5% level: a double asterisk indicates that the difference is significant at the 1% level.

TABLE 7.11.4. THE INTERPRETATION OF THE SEVEN CLUSTER SOLUTION

Cluster	Percentage of cluster intending to study A-level physics	Percentage of cluster intending to study in the sixth-form	G.C.E. entrants	Characteristics
A_1 (N = 86) 70% boys	94	100	94	Neurotic, high achieving pupils who find the subject easy. IMPORT, ITS and PHYSID scores are all high, as are classroom variables MATCH and VARUND(E). Poor study habits.
A_2 (N = 120) 92% boys	93	100	97	Stable introverts with the best attainment in physics. Attitude and favourable classroom variable scores are all high. Motivation IMPORT and LIE scores are high. Study habits are good. Physics is rated easy.
B (N = 65) 62% boys	37	83	85	Poor attitudes towards physics with a high degree of classroom mis-match.
C (N = 64) 75% boys	2	53	30	Poorly motivated extraverts. Lowest attainment. Poor attitudes to physics. High degree of mis-match.
D_1 (N = 66) 94% boys	0	3	70	Stable, poor achieving pupils with average attitudes who like the teacher's style
D_{2A} (N = 70) 51% boys	1	100	99	Neurotic extraverts with poor attitudes towards physics which is found difficult. Study habits in physics are poor. Classrooms satisfy the pupils' need for VARUND teaching. LIE scores low.
D_{2B} (N = 76) 53% boys	17	100	91	Stable introverts, well motivated with good study habits. High LIE scores. Moderate attitudes, IMPORT and attainment.

7.11.3. SEX DIFFERENCES WITHIN THE CLUSTERS

Table 7.11.5 shows the significant sex differences between cluster variables. Of particular interest is the superior achievement shown by the girls in the two major physics choosing clusters of A_1 and A_2. It is also notable that girls display a greater preference for the varied, teaching-for-understanding approach when there are significant differences in this variable.

TABLE 7.11.5. SEX DIFFERENCES WITHIN THE CLUSTERS

Cluster	Variable	Mean score (Standard deviation) Boys	Girls
A_1 (65 boys, 21 girls)	VARUND(P)	25.82 (2.47)	27.10 (2.02)*
	STUDYHAB	3.63 (1.41)	4.57 (1.54)*
	NEUROT	12.09 (3.48)	13.86 (3.28)*
	PERFORM	4.11 (1.31)	5.19 (0.68)**
A_2 (110 boys 10 girls)	STUDYHAB	6.51 (1.55)	7.50 (0.85)*
	PERFORM	4.49 (1.10)	5.20 (0.63)*
B (40 boys 25 girls)	LBE	23.43 (3.31)	19.40 (3.61)**
C (48 boys 16 girls)	IMPORT	2.47 (0.68)	2.06 (0.57)*
D_{2A} (36 boys 34 girls)	IMPORT	3.08 (0.60)	2.77 (0.65)*
	VARUND (M)	1.69 (2.51)	3.03 (1.82)*
D_{2B} (40 boys 36 girls)	VARUND (P)	25.28 (2.35)	26.78 (2.09)**

**p < 1%; * p < 5% (t-test)

Cluster D_1 shows no significant sex differences

7.11.4. ACADEMIC SUCCESS WITHIN THE CLUSTERS

Table 7.11.6 gives a breakdown of G.C.E. and C.S.E. success in terms of the seven clusters. Statistics from the Department of Education and Science (D.E.S., 1979 and 1980) show national pass-rates in O-level physics of 60.5% and 59.3% respectively for the years of 1977 and

TABLE 7.11.6. OVERALL ATTAINMENT IN G.C.E. AND C.S.E. PHYSICS

Cluster	Number of GCE entrants	Number passing	% passing	Number of CSE entrants	Number achieving Grade 1	A-level physics choosers: Number of GCE entrants	Number passing	% passing	Number of CSE entrants	Number achieving Grade 1	Potential sixth formers rejecting A-level physics: Number of GCE entrants	Number passing	% passing	Number of CSE entrants	Number achieving Grade 1	Leavers: Number of GCE entrants	Number passing	% passing	Number of CSE entrants	Number achieving Grade 1
A_1	81	69	85.2	5	0	79	67	84.8	2	0	2	2	100	3	0	0	-	-	0	-
A_2	116	103	88.8	4	0	109	96	88.1	2	0	7	7	100	2	0	0	-	-	0	-
B	55	39	70.9	10	2	22	18	81.8	2	1	24	15	62.5	6	0	9	6	66.7	2	1
C	119	3	15.8	45	0	0	-	-	1	0	8	1	12.5	25	0	11	2	18.2	19	0
D_1	46	19	41.3	20	2	0	-	-	0	-	0	-	-	2	0	46	19	41.3	18	2
D_{2A}	68	40	58.8	2	0	1	1	100	0	-	67	39	58.2	2	0	0	-	-	0	-
D_{2B}	69	49	71.0	7	0	11	8	72.7	1	0	58	41	71.0	6	0	0	-	-	0	-
ALL	454	322	70.9	93	4	222	190	85.6	8	1	166	105	63.3	46	0	66	27	40.9	39	3

There are no significant differences between the pass rates for boys and girls, although the pass rates at O-level for girls in clusters A_1 and A_2 (N = 21 and N = 10) respectively) are both 100%.

1978. By this criterion, the pupils of clusters A_1, A_2 and D_{2B} have above average and those of clusters C and D_1 below average national achievement characteristics (chi-squared test).

7.11.5. PUPIL STEREOTYPE A_1 - THE SYMPATHETICALLY TAUGHT, ANXIOUS PHYSICISTS

This is one of the two major groups of A-level physics choosers. A_2 is the other. Appendix 7.11.4. explores mean score differences between these two clusters. The ratio of boys to girls in cluster A differs little from the survey sample as a whole. The dominating personality characteristic is anxiety or neuroticism. This might be said to be reflected in the low study methods score: the pupils are uncertain as to the worth of their study techniques. However, this uncertainty does not adversely affect their motivation especially in physics where motivation to do well is indicated by high scores on IMPORT and PHYSMOT.

These pupils receive the strongest exposure to the varied, teaching-for-understanding classroom style, which matches their classroom environment preferences very closely (high MATCH score and low VARUND mis-match score).

There is strong identification with physics, as expressed by the subject enjoyment variable PHYSID and a correspondingly high 'image' rating (SAT). The correlation between these two variables at 0.22 is just significant at the 5% level.

Physics achievement is the second highest of all the seven clusters. Multiple regression was used to 'predict' achievement and enjoyment/commitment using the sixteen continuous variables of table 7.11.3. Enjoyment/ commitment was used as an additional variable in the prediction of achievement.

As table 7.11.7. shows, with all the variables in the regression equation, only physics examination motivation (IMPORT) achieves a significant beta-weight. Limiting the regression equation to what, in effect, are the most highly correlated variables by constructing the equation hierarchically gives a clearer picture of the more significant variables.

TABLE 7.11.7. PREDICTOR VARIABLES FOR TYPE A_1 PUPILS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
IMPORT	0.39	IMPORT	0.39
Multiple correlation with all cluster variables	0.64	Multiple correlation with all cluster variables	0.58
EXTRAV	-0.32	IMPORT	0.43
MOT	0.31	SAT	0.20
IMPORT	0.27	ITS	0.20
ITS	0.21		
Multiple correlation with the four variables above	0.51	Multiple correlation with the four variables above	0.49

The lower half of the table refers to a restricted regression equation.

This group of A-level physics choosers does not find the subject as easy as does group A_2, for instance, but academic motivation (MOT); the need to do well in the examination (IMPORT); the personality characteristic of introversion; a high physics 'image' or satisfaction rating, and a teaching approach which pleases these anxious pupils (a high ITS score in association with the classroom environment MATCH), are all related to achievement and enjoyment/commitment.

Of the 86 pupils in this group, 21 are girls. All the pupils intend to study in the sixth-form, with 93% choosing A-level physics. The most often given reason for this choice (81% of cases) is the need for career qualifications. The second most popular reason, given by 73% of the pupils is intrinsic subject interest.

The main reasons given by pupils rejecting A-level physics are those related to subject difficulty at O- and A-level.

The main career areas for 64% of the pupils are in pure and applied sciences.

The attributes of the pupils in this cluster are such that they warrant the description of '<u>anxious physicists in sympathetically taught classes</u>'.

Further information about the pupils of this cluster can be obtained by factor analysing the scores on the continuous variables of table 7.11.3 , with the mis-match VARUND (M) excluded because of its direct relationship to the other two VARUND variables (Youngman, 1979, page 96). It was hoped that sufficient variance was present in the remaining fifteen cluster variables to permit principal components factoring. The other two criterion variables had not been used to define the cluster groups and were not suspect in this respect. After an oblique rotation of the factor axes, six recognisable factors (table 7.11.8) confirmed that the factor technique was capable of a valid application within the cluster.

TABLE 7.11.8. FACTORS IN CLUSTER A_1

Factor	Variable	Correlation with factor score	Description
I	MOT	0.96	Motivation. A general factor
(12.9%)	PHYSMOT	0.82	(Section 7.10.5.)
II	STUDYHAB	0.96	Study Habits.
(12.6%)	PHYSHAB	0.71	A general factor (Section 7.10.5.)
III	VARUND (P)	0.55	Teaching style factor. A measurement of pupil-classroom match inclusive of
	VARUND (E)	0.69	the need to provide varied, teaching-for-understanding. A form of the general
(11.4%)	MATCH	0.61	factor (Section 7.10.5.)
IV	EXTRAV	0.61	High attainment by anxious introverts
	PERFORM	-0.59	
(10.6%)	NEUROT	0.52	
V	IMPORT	0.83	Pupils who want to do well in the
	LBE	0.37	examination also want to learn by
(8.6%)			experiment
VI	PHYSID	0.62	'Feeling for physics'. Measures the
	SAT	0.39	attractiveness of studying physics in
(8.2%)	ITS	0.36	terms of the teaching style, subject material and lesson enjoyment. A form of the general factor (Section 7.10.5.)

Variance accounted for by each factor appears in brackets

Four of the factors of table 7.11.8. have already appeared in the earlier broad fifth-form group analysis of Section 7.10. These are the general factors of motivation, study habits, teaching style and subject enjoyment. The further identification of a high achieving, anxious introvert factor IV is consistent with the cluster structure of this group of pupils, where anxiety is a strong characteristic. The pupils who are keenest to do well in the examination are those most likely to learn-by-experiment (factor V), which has further implications because, according to the regression analysis, it is examination motivation which is most strongly related to all-round successful classroom outcomes.

A check-list of behaviours required of teachers to identify and effectively teach A_1-type pupils would include:

Item 1: Pupil personality

A_1-type pupils are anxious introverts. These are pupils who fit into the conventional school environment of academic study and homework relatively easily but who need reassurance and benevolent guidance to perform efficiently.

Item 2: Cognitive ability in physics

The teacher's normal array of cognitive lists will have identified the above average A_1-type pupils.

Item 3: Pupils intentions after the fifth-form

All will be staying on and nearly all will take physics.

Item 4: Pupil motivation

Assessing pupil motivation requires an extensive experience of teaching a class, as was demonstrated in Section 5.3.5. An alternative approach would be to use the modified 'Rowntree' scale of Section 5.3. A_1-type pupils have high physics motivation.

Item 5: Pupil study skills

Formal instruction in optimum study habits will be necessary rather than leaving these anxious pupils to acquire such skills by chance. Such instruction would be more necessary for the boys than for the girls.

Items 6/7/8: Matched learning environment/learning-by-experiment/varied, teaching-for-understanding

Girls are likely to prefer more of the varied/teaching-for-understanding method than the boys. Lessons should be presented by the teacher in a positive, interesting manner with the opportunity for learning-by-experiment. Although the lesson organisation variables have not been shown to be directly associated with the criteria outcomes for A_1-type pupils, lesson organisation as measured by the experience of varied/teaching-for-understanding and classroom match are strong characteristics for these pupils.

A_1-type pupils enter their physics classrooms with only average academic achievement motivation but an anxious personality disposition. Arguably, as a result of their favourable experiences in class, they become more strongly motivated towards physics, and identifying more closely with the subject, commit themselves to A-level studies in it. For these anxious pupils, it would appear that a benevolent guidance element should qualify check-list items 5 and 6 for the most effective classroom outcomes.

Under the circumstances which A_1-type pupils find themselves in the present survey, introversion has a strong association with attainment. This personality trait is brought by the pupil into the classroom and is not susceptible to teacher manipulation as are the environment variables. Thus, the 'intermediate', guided-discovery teaching style (Section 2.8 and 7.4), to which A_1-type pupils are exposed, seems most suited to introverts, at least in terms of attainment outcomes.

7.11.6. PUPIL STEREOTYPE A_2 - THE ACADEMIC ACHIEVEMENT MOTIVATED, 'NATURAL' PHYSICISTS

This is the other major group of A-level physics choosers. It is strongly male oriented. The personality type is (from table 7.11.3) clearly the stable introvert. The relatively high LIE score is likely to be a measure of an organised and conventional approach to social situations (Sections 7.3.5 and 7.12). Study methods and motivation in all academic subjects, as well as physics are highly positive. Physics is found particularly easy, which is a result unique to A_2-pupils.

The classroom environment is relatively well matched to pupil preferences. The teacher's style of teaching is in itself interesting, while the methodology exemplifies the varied, teaching-for-understanding model.

Physics as a modern subject of high prestige and excitement is rated very highly on the comparative subject attitude scale (SAT).

Success in the physics examination is rated as very important, which is consistent with the other motivation ratings of the pupils in this group. Attainment in physics, almost exclusively of G.C.E. standard, and attitudes towards the subject (PHYSID) are superior to all the other groups. There is no significant correlation between PHYSID and the comparative subject satisfaction variable, however.

Taking into account the typical personality attributes of science students (Entwistle and Wilson, 1977), the pupils of this group might be described as embryonic higher education science students. In this survey, they are the academic achievement motivated, 'natural' physicists. Of the 120 pupils, (10 girls, only), 111 intend to study physics at A-level. The most often expressed reason for doing so is that it would be needed for career purposes later (given by 83%). The second most popular reason (given by 77% of pupils) is intrinsic subject interest.

The pupils not intending to study A-level physics give career requirements and restrictions on sixth-form choice combinations as the strongest rejection reasons.

For 63% of the pupils, the expressed career area is pure or applied science.

Using multiple regression to 'predict' attainment and enjoyment/commitment as explained in Section 7.11.5 , gives the results of table 7.11.9. Academic achievement motivation is the strongest predictor of attainment. Motivation in physics and the two classroom environment variables (MATCH and ITS) are strong predictors of enjoyment/ commitment.

TABLE 7.11.9. PREDICTOR VARIABLES FOR TYPE A_2 PUPILS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
MOT	0.35	PHYSMOT	0.51
STUDYHAB	-0.30	MOT	-0.29
ITS	-0.28	MATCH	0.19
SLOG	-0.20	ITS	0.19
Multiple correlation with all cluster variables	0.53	Multiple correlation with all cluster variables	0.61

A notable difference between A_1-type and A_2-type pupils is that the 'interesting teaching style' variable displays an opposite association with attainment. The element of stability in the personality make-up of this male oriented group appears to make them more independent of the teacher influence than type A_1 pupils (see below). Consequently, an interesting teaching style is no longer associated with high attainment. Indeed, the negative relationship for A_2-type pupils could well be due to high achievers being taught by teachers whose style was far from interesting.

Factor analysing the continuous variables, excluding VARUND (M), by the principal components method, followed by an oblique rotation of the factor axes, gave five recognisable factors. As table 7.11.10 shows, two of these were the general ones of study habits and motivation.

TABLE 7.11.10. FACTORS IN CLUSTER A_2

Factor	Variable	Correlation with factor score	Description
I	MOT	0.88	Motivation.
(15.8%)	PHYSMOT	0.86	A general factor (Section 7.10.5.)
II	PHYSHAB	1.00	Study habits.
(10.7%)	STUDYHAB	0.76	A general factor (Section 7.10.5.)
III	VARUND (P)	0.79	Teaching-for-understanding continuum.
			High scores indicate pupils who demand
	VARUND (E)	0.54	a comprehensive provision of this type
			of teaching and get it. Low scores
(10.2%)			indicate less demand and less provision
IV	PERFORM	-0.53	'Feeling for physics' demonstrated by
	SLOG	0.44	high achieving introverts (reversing
	EXTRAV	0.42	the coefficients). Correlates
	PHYSID	-0.39	significantly at 0.24 with motivation
(8.1%)			factor I)
V	LBE	0.71	Learning-by-experiment. The subject
	SAT	0.31	image is enhanced for pupils who see
(7.2%)			the need for this type of learning

Variance accounted for by each factor appears in brackets

The appearance of the varied, teaching-for-understanding continuum suggests that A_2-type pupils are less influenced by their environment than are the A_1-type. If A_2-type pupils prefer a particular provision, they tend to experience it in the classroom: if it is not their preference, then they tend not to experience it. Classroom match scores are high, but are only average on the major classroom variable of VARUND (mismatch). The evidence here is that the A_2-type pupils can settle in and presumably work effectively in a range of environments. There is an element of 'slotting into the system' - of taking the classroom as they find it. From Appendix 7.11.4 , it is clear that A_2-type pupils find physics a lot easier than do A_1-type pupils. They also have higher academic achievement motivation and study habits scores. As A_2-type pupils are also more emotionally stable, a picture emerges of pupils who are more self-reliant, less dependent upon teacher support, and whose ability, introversion and motivation bring them success in a difficult subject rather than particularly structured lesson experiences. (There is evidence of this from table 7.11.25, where A_2-type pupils in badly mis-matched classes show no significant differences in attainment despite suffering this experience. Unfortunately, with only one A_1-type pupil in a mis-match class, it is not possible to proceed further to compare effects on pupil types).

The negative association with between good study habits and poor attainment, which appears in table 7.11.9, is possibly more a reflection of the most able students, who find the subject easy, neglecting the more rigorous study techniques that find consensus expression in the study habits scale. The less able pupils in this cluster who find the subject less easy would be keen to prepare their work conscientiously because of their high motivation and stable, introverted personalities but, nevertheless, would be unable to achieve the highest grades.

Although A_2-type pupils seem relatively impervious to certain of the teacher variables, characteristic factor V in table 7.11.10 shows that an appreciation of learning by experiment is associated with the modern image of physics.

In drawing up a check-list for A_2-type pupils, the reality of the classroom has to be taken into account. It is unlikely that a physics class will consist entirely of stable introverts of this pupil type. Unless some relatively unconventional, individualised learning approach is adopted, class-teaching is almost inevitable. Thus, it is quite unrealistic to suggest that A_2-type pupils in a class should not be instructed in study-skills or given a 'matched' learning environment while so accommodating A_1-type pupils in these respects. As the structure of a class builds up; A_1-type pupils, A_2-type pupils, B-type pupils etc., the developing check list will subsume its predecessor, as long as the research evidence does not suggest that such a procedure would adversely influence one of the other pupil groups. Should the latter actually happen, then the need for systematic change in classroom organisation away from the class as a 'unit' will have been demonstrated.

A_2-type pupils bring into the classroom their stable, introverted personality characteristic; strong academic motivation and, very probably, high intellectual ability. None of these are susceptible to manipulation by the physics teacher and considering the achievement and attitudinal outcomes, little would be gained by trying to improve further. However, the quality of the learning experience is firmly in the teacher's hands, so an appropriate emphasis on learning-by-experiment would be expected to contribute to comparative subject satisfaction. Indeed, check-list item 6, which includes learning-by-experiment as well as varied, teaching-for-understanding, if implemented wholeheartedly with A_2-type pupils might encourage these intellectual pupils to recognise the place of the experiment in physics and hence gain a more expansive view of their likely sixth-form subject.

The only modified check-list for A_2-type pupils is

Item 1: Pupil personality

A_2-type pupils are stable introverts and unlike A_1-type pupils display little anxiety and are capable of a much higher degree of effective independent work.

7.11.7. PUPIL STEREOTYPE B - MODERATE ACHIEVERS IN HIGH MIS-MATCH CLASSES

This is a group of 40 boys and 25 girls. Some 24 intend to go on to A-level physics. The group includes 11 leavers.

The strongest characteristic, without doubt, is the extreme degree of mis-match between preferred and received teaching instruction. Scores on MATCH and the teaching-for-understanding classroom styles are the lowest of all the groups, yet the need for the teaching-for-understanding approach is more highly demanded by these pupils than by any others. Consequently, the teacher's style gets a very low interest rating.

Motivation, study habits, attainment, personality and subject difficulty variables are all unremarkable, but such is the strength of the classroom antipathy to the method of presentation that subject attitudes are poor (SAT and PHYSID). The distinction shown by groups A_1 and A_2 between the enjoyment, 'nature' of physics variable, PHYSID, and the comparative subject satisfaction or 'image' variable (SAT) disappears somewhat with group B, where there is a highly significant intercorrelation of 0.48. Group B pupils simply do not like the subject.

Given such a dislike of the subject, it is surprising to see as many as 24 pupils intending to study the subject further. The reason given by 17 of these pupils is an expected good G.C.E. performance in physics, but, with 23 pupils opting for scientific careers, it is clear that pupils are having to over-ride their natural feelings about the subject to satisfy career requirements. Indeed, 21 of the 24 pupils specifically mention career demands as a reason for A-level physics study.

Reasons for not taking A-level physics given by the 30 pupils staying on are mainly concerned with the uninteresting nature of a theoretical subject, unattractively taught with insufficient experimental work in which expected attainment was low.

Table 7.11.11 shows the results of the regression analysis which attempted to identify the variables most strongly associated with attainment and attitude (PHYSID).

TABLE 7.11.11. PREDICTOR VARIABLES FOR TYPE B STUDENTS

Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
MATCH*	0.24	SAT MATCH	0.35 -0.26
Multiple correlation with all cluster variables	0.52	Multiple correlation with all cluster variables	0.63
PHYSMOT**	0.25	PHYSMOT MATCH	0.42 - 0.27
Multiple correlation with all cluster variables	0.51	Multiple correlation with just the two variables	0.47

An asterisk indicates that the variable contribution does not reach significance at the 5% level but that its beta-weight is greatest.
A double asterisk indicates that although the variable makes a significant contribution to the regresssion equation as constructed with the beta-weight given, in the full equation its contribution is insigificant.
The lower half of the table refers to the regression equation when variable SAT is excluded.

Using all the variables in the attainment equation produces a moderate overall multiple correlation at 0.52, but at no stage during the analysis does any one variable make a significant contribution (at the 5% level) to the equation by itself. The pupil preference/received teaching style, MATCH, variable is shown simply because it achieves the highest beta-weighting in the full equation. It is hazardous to proceed much further, mainly because of the very low MATCH scores achieved by these pupils.

Building an all variable equation to associate with attitude (PHYSID) inevitably flounders on the strong inter-correlation between PHYSID and the satisfaction or 'image' scale, SAT, for this group of pupils. To explore the importance of other variables, it was decided to remove the satisfaction variable from the analysis, and the bottom half of table 7.11.11 shows the results of this modified analysis (for attainment as well as attitude). The physics motivation variable, PHYSMOT, is now seen to be of some importance in both the regression equations. The best attainment and attitudes are displayed by Group B pupils who are able to maintain their academic motivation towards the study of physics despite the apparent unsuitability of the classroom environment.

The negative weighting of the MATCH variable in the attitude equation should be treated with the caution advocated earlier because of the very low raw MATCH scores in this group.

Overall, pupils in group B might be described as 'moderate achievers in high mis-match classes'.

The results of factor analysing the continuous variables, excluding VARUND (M), by the principal components method with an oblique rotation of the factor axes appear in table 7.11.12.

The deficiencies in the classroom environment cause a substantial number of pupils to reject physics in the sixth-form. This suggests that factor III in table 7.11.12 should be interpreted as a mis-match in the provision of varied, teaching-for-understanding, which

TABLE 7.11.12 FACTORS IN CLUSTER B

Factor	Variable	Correlation with factor score	Description
I (18.5%)	PHYSMOT MOT	0.85 0.59	Motivation. A general factor (Section 7.10.5.)
II (10.4%)	PHYSHAB STUDYHAB	-0.98 -0.88	Study habits. A general factor (Section 7.10.5.). (Good study habits correlate at 0.25 with attainment)
III (9.7%)	MATCH VARUND (E) EXTRAV	0.57 0.53 0.47	Teaching style factor. Measures pupil 'match' and the varied, teaching-for understanding. A general factor (Section 7.10.5.) but here associated with extraversion
IV (8.8%)	ITS SAT	0.88 0.43	Attractive subject image
V (7.0%)	SLOG PHYSID	0.51 -0.46	Subject antipathy
VI (6.4%)	PERFORM NEUROT	-0.78 0.28	Attainment. Anxious pupils tend to get low grades
VII (6.1%)	LIE EXTRAV MATCH	0.63 -0.38 -0.36	Mis-matched, socially conforming introverts factor

Variance accounted for by each factor appears in brackets

is most keenly felt by the introverted pupils. Factor VII, which does not correlate with factor III, shows that the introverts experience a general mis-match in the provision of classroom activities. A further consequence of the mis-match and poorly rated teaching style is that the image of the subject suffers as shown by the ITS/SAT factor, which is perhaps more appropriately described as 'unattractive subject image'.

The major item on the teacher's check-list for B-type pupils is the provision of a suitable classroom climate for learning. This is a strong re-iteration of check-list items 6/7/8, but it is worthwhile to emphasise here the suspect classroom activities more precisely (Section 5.4.5). These are:

a) understanding ideas by explaining in simple terms;

b) using words rather than mathematical formulae whenever possible;

c) linking the topics in an understood concept hierarchy;

d) setting homework that is linked to the lesson;

e) planning smooth running lessons which include pupil experiments, teacher demonstrations and audio-visual techniques, and

f) teacher guided learning with lesson notes made by varied procedures.

It might well be that a teaching style oriented to satisfy these six dimensions will, by itself, be rated by these pupils highly on the interesting teaching style scale. Whether this is so or not,and the personality of the individual teacher might be the determining element, one of the major reasons for rejecting A-level physics by B-type pupils will have been removed.

Solving the pupil-teacher mismatch, and positively teaching study skills (factor II) to make use of the positive attainment association,could lead to the elimination of the B -type pupil group and, hence, enhance the popularity of physics amongst a strong potential sixth-form population.

7.11.8. PUPIL STEREOTYPE C - 'GOOD-TIME', POOR ACHIEVING EXTRAVERTS

Referring to table 7.11.6, just one pupil chooses A-level physics from the 48 boys and 16 girls in this group. Some 45 pupils are taking the C.S.E. physics examination so are not really potential sixth-form physicists. Also, there is a large proportion of leavers, 30 out of the 64 pupils in all.

The scores in table 7.11.3 show clearly the nature of this group. Very low scores on all the academic motivation, study methods, attitudes to physics and attainment are accompanied by high extraversion scores. Pupils of this type, who are often so alienated by the school environment (Sumner and Warburton, 1972), are as likely to rate the varied, teaching-for-understanding approach lowly, as indeed they do, because of their disillusionment in trying to study academic subjects. (This group finds physics the most difficult). Even so, it is notable that C-type pupils do record the highest demand for learning by experiment, although the rating fails to reach a statistically significant level.

The career intentions of the pupils in this group are to be found in the manual, social and conventional business areas. Just 5 pupils intend working in scientific or technological fields. Of the 33 pupils remaining at school, 30 give O-level/C.S.E. difficulty and an anticipated poor grade as reasons for giving the subject up, while about half of the pupils refer to the lack of experimental work in an uninteresting, unattractively taught course.

The regression technique for this group illustrate a characteristic peculiar to the extraverted pupils. Table 7.11.13 shows that, although none of the variables alone is strong enough to show a significant association with attainment, the highest beta-weight is the negative value of -0.29 achieved by the criterion attitude variable

TABLE 7.11.13. PREDICTOR VARIABLES FOR TYPE C STUDENTS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
PHYSID *	-0.29	MATCH	-0.40
		ITS	0.28
Multiple correlation with all cluster variables	0.45	Multiple correlation with all cluster variables	0.72
		MATCH**	-0.49
		ITS**	0.34
		EXTRAV**	0.24
		PHYSMOT**	0.22
		Multiple correlation with all variables marked **	0.66

A single asterisk indicates that although the variable contribution to the final regression is insignificant, during the construction of the equation it is the only variable to achieve a significant beta-weight.
A double asterisk indicates a variable which contributes significantly to a restricted regression equation made up entirely of variables so marked.

of PHYSID. This is one of the rare occasions where the two classroom outcome criteria are significantly related, although unfortunately, the effect is a negative one. (In the hierarchical construction of the regression equation, the contribution of the variance of the variable PHYSID does reach significance in association with a particular sub-set of the other variables). Nevertheless, an examination of the regression equation for PHYSID itself suggests a possible explanation.

Variable PHYSID is negatively associated with classroom match, which is itself rather an odd relationship, and positively with the interesting teaching style variable. Thus, it can be hypothesised that the sociable extraverts enjoy their relationships with their teacher - they may learn little but they do have a good time - and the PHYSID scale is, in part, measuring this social aspects of being in the physics class rather than identifying with physics or enjoying the subject material. If this is so, relatively high PHYSID scores might be achieved despite low MATCH scores, as the negative correlation suggests. Further, this interpretation of PHYSID would explain any negative association with attainment; pupils with socially high PHYSID scores could well have ceased to make any real progress in physics and might reasonably expect only low examination grades (hence the weak examination motivation scores).

C-type pupils earn the description of '<u>good-time, poor achieving extraverts</u>'. Pupils like these, achieving little in real learning but, at a superficial level, liking what they do because little is asked of them with their poor motivation and study habits, were identified by Sumner and Warburton (1972) in their research on possible problem areas when the school leaving-age was last raised.

Table 7.11.14 shows the results of factor analysing the continuous variables, excluding VARUND (M). Six recognisable factors can be seen after an oblique rotation of the factor axes.

TABLE 7.11.14. FACTORS IN CLUSTER C

Factor	Variable	Correlation with factor score	Description
I	STUDYHAB	0.98	Study habits.
(15.8%)	PHYSHAB	0.74	A general factor (Section 7.10.5.)
II	SAT	0.69	Attractive subject image to
	NEUROT	0.51	anxious pupils
(13.0%)	ITS	0.46	
III	EXTRAV	-0.71	Extraverts preferring to learn by
	LBE	-0.64	experiment (reversing the sign of
(11.6%)	LIE	0.51	the correlations)
IV	VARUND (E)	0.67	Association of examination motivation
	IMPORT	-0.64	and low teaching-for-understanding
(9.3%)	VARUND (P)	0.50	provision (reversing the sign of the correlation)
V	MATCH	0.70	'Feeling for physics' associated with poor classroom
(8.1%)	PHYSID	-0.48	'match'
VI	PERFORM	-0.50	Attainment through academic
(6.8%)	MOT	-0.35	motivation (reversing the sign of the correlation)

Variance accounted for by each factor appears in brackets

The subject attitude components of factors II and V must generate very low factor scores, as shown by the mean scores of table 7.11.3. Where C-type pupils do score highly is on the 'extraversion/learning-by-experiment' factor. These pupils, who are predominantly extraverted and from the presence of the LIE variable unlikely to be socially conforming, desire to learn by concrete, direct experience of physical events. The provision of such learning experiences is thus desirable.

The appearance of the learning-by-experiment factor with these pupils, at first sight, seems to indicate that the varied, teaching-for-understanding approach, which incorporates the appropriate learning should be adopted much more strongly. However, an inspection of the cluster means in table 7.11.3 shows that preference for this type of teaching is scored in the reverse direction to that of the other groups. For C-type pupils, this style of teaching with its emphasis on understanding is not popular. The two characteristic 'academic-skills' factors, I and VI, both of which give low scores (from table 7.11.3) confirm that these pupils are misplaced in an academic physics course.

Teachers' check-list item 4, motivation, is a key one. Without the drive to want to succeed little improvement in C-type pupils performance can be reasonably expected. To improve motivation, success at a concrete level would be a start. (Eisenhardt, 1977). The course, probably not G.C.E. physics and possibly not (mode 1) C.S.E. physics either, should be organised to provide practical learning skills. For particular interest areas, pupils would develop and progress by generating their own internal self-motivation (Sumner and Warburton). In science, a mode 3-type physics or a modified form of the Nuffield Secondary Science scheme would appear suitable. The implication here is that a flexible classroom organisation (a new check-list <u>item 9</u>) is needed to accommodate

C-type pupils. With a learning scheme more compatible to their needs, these pupils are likely to begin to acquire a more genuine interest and enjoyment in the subject.

Another item on the initial check-list of some significance for C-type pupils would be <u>item 2 - pupil cognitive ability in physics</u>. The teacher's array of cognitive testing schemes should be able to identify those pupils at an early stage who find it difficult to master the higher thinking abilities and whose learning is best accomplished in real concrete terms.

The personality check-list (1) requires the trait of extraversion to be recognised. Extraverted C-type pupils do not fit comfortably into the conventional classroom scheme of activities. They will want to originate and initiate exchanges with the teacher and their fellow pupils. <u>They</u> desire to be the centre of attraction, rather than the teacher. To them, exchanges at a social level are preferred to internal, introspective, contemplative activities. Their internal drive and enthusiasm is generated in response to external social pressures. It is clear from this, that book-learning and the mental discipline to build up thinking strategies for problem-solving and concept-learning in academic subjects will not come naturally to such pupils. Nevertheless, some extraverts are successful in these respects, but as Entwistle and Wilson (1977) and others have pointed out, it is only when extraverts are able to control their natural ebullience (and then because they want to, not because they are forced to) that they achieve the intellectual mastery that comes more easily to introverts.

If, in the early years of secondary education, learning experiences in physics are of such a practical nature that the extraverts are able to build up, through success in studying physics, their own individual motivation rules, and if, in the later years, classroom organisation is sufficiently flexible for these pupils to use their extraversion positively, in grouped practical work and discussions for instance, then extraverts would have an even better chance of success in this academic subject.

7.11.9. PUPIL STEREOTYPE D_1 - WELL ADJUSTED, POOR ACHIEVING LEAVERS

The mean scores of table 7.11.3 show that these 66 pupils (of whom just four are girls) display average motivation, study habits and attitudes to physics. Personality characteristics show a bias towards emotional stability. Just two of the pupils intend to go on to study A-levels. The majority of the pupils will be leaving to enter manual occupations, although some 12 pupils in all will be continuing with their education at school or at a Further Education college.

None of the pupils intend to continue with physics. The only variable which shows that the pupils might have any positive affinity with physics is 'interesting teaching style', which shows the highest rating of all the groups. However, student attainment is poor, being the second worst of all the groups. The two potential A-level students reject physics because of its perceived difficult and mathematical nature.

Using multiple regression to identify the most strongly predicting variables (table 7.11.15) shows that the strongest variable associated with attainment is the attitude criterion of enjoyment/commitment to physics, although scores on this variable are much inferior to those gained by the A-level physics choosing groups A_1 and A_2. There is a significant simple correlation (at the 5% level) of 0.31 between enjoyment/commitment and attainment.

TABLE 7.11.15. PREDICTOR VARIABLES FOR TYPE D_1 STUDENTS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
PHYSID*	0.20	SLOG	-0.32
		VARUND (M)	0.27
		ITS	0.23
Multiple correlation with all cluster variables	0.52	Multiple correlation with all cluster variables	0.70

A single asterisk indicates that although the variable does not make a significant contribution to the final regression equation it is the only variable to reasch significance during the construction of the equation.

Subject enjoyment/commitment as a criterion depends most strongly on (i) perceived easiness and (ii) how closely the actual teaching method matches up to the varied, teaching-for-understanding style. The latter is represented by its mis-match variable (a high score indicating insufficient classroom practice) so the relatively high beta-weight achieved could mean that, if classroom practice includes little of this type of teaching, attitudes tend to be better. Attitudes are also enhanced if the subject is found easy and the teaching style is, itself, rated as interesting.

The interpretation of an apparently anomalous varied/teaching-for-understanding effect is assisted by the appearance of a factor for D_1-type pupils (table 7.11.16), which shows that this particular teaching approach/pupil preferred style exists as a continuum, where pupils who demand little of this method tend to get little and those who demand more tend to get more. However, if D_1-type pupils are divided into two groups on the basis of their preferred VARUND (P) scores, the higher preference scorers experience the greater mis-match [VARUND (M) in Appendix 7.11.5]. As higher preference scorers tend to find physics easier and have the better attitudes (although not significantly so, Appendix 7.11.5), the appearance of the mis-match variable in the regression equation is thus accounted for. Rather than a low provision of VARUND type teaching in general, the mis-match beta-weight is indicative of pupils who like physics expressing a significantly stronger preference for this varied, teaching -for-understanding method.

TABLE 7.11.16. FACTORS IN CLUSTER D_1

Factor	Variable	Correlation with factor score	Description
I	MOT	0.86	A modified motivation factor
	PHYSMOT	0.82	(Section 7.10.5.)
(16.9%)	IMPORT	0.35	
II	PHYSHAB	-0.96	Study habits.
(11.8%)	STUDYHAB	-0.84	A general factor (Section 7.10.5.)
III	VARUND (E)	0.85	Teaching-for-understasnding continuum
(10.7%)	VARUND (P)	0.66	(see table 7.11.10.)
IV	PHYSID	-0.71	'Antipathy to a difficult subject'.
	SLOG	0.69	Correlates significantly at 0.24 with
(7.3%)	PERFORM	-0.45	motivation factor I
V	LBE	0.70	Learning-by-experiment pupils in poorly
(6.8%)	MATCH	-0.30	matched classes
VI	ITS	-0.38	Teaching style attractive to
(6.6%)	EXTRAV	0.36	introverts (correlations reversed)

Variance accounted for by each factor appears in brackets

This group of leavers display better attitudes and achieve more than type C pupils, a majority of whom will be remaining at school. The unique factor of 'antipathy to a difficult subject' brings together both the major criterion variables of attainment and subject identification. For D_1-type pupils, <u>subject difficulty is associated with poor attainment and moderate attitudinal outcomes</u>.

To lessen the perceived difficulty of physics, the solution suggested for type C pupils could be adopted, although not entirely for the same reasons. Learning by direct experience of physical concepts through experimental work is not required for type D_1pupils because of personality problems, but it is needed to allow the pupils to build up systems of familiar rules of physical behaviour into which new learning is able to fit and be explained (Gagné, 1970, and Section 2.6). Factor V in table 7.11.16 shows that in poorly matched classes, the pupils are more likely to express the need for the learning-by-experiment method.

In personality terms, it is the introverts who are likely to be attracted by the teacher's style (Factor VI), which from the regression equation has an association with subject enjoyment/commitment.

As D_1-type pupils can be described as 'well-adjusted, poor-achieving leavers', the teacher should be able to identify this stereotype without too much difficulty. Teacher check-list item 6

matching the learning environment to pupil's preferences

requires careful consideration. Despite the overall neutral responses to the teaching-method variables (table 7.11. 3), it appears that there is some variation in pupil preferences in cluster D_1, with some pupils requiring more of the varied, teaching-for-understanding method while others are relatively satisfied. To check on the amount of classroom match, the appropriate questionnaire (Section 5.4) might be administered to identify the needs of the individual pupils. What is then required is a flexible classroom arrangement (check-list item 9) which allows both the low and the high VARUND-type learners to make progress in a learning-by-experiment environment. To accommodate the needs of the high scorers, who tend to show a greater appreciation of the problem-solving nature of physics (Appendix 7.11.5), the varied learning techniques of the VARUND style should be employed, but for the low scorers an environment more akin to that for type-C pupils with less emphasis on understanding and more on concrete acquaintance should be created.

7.11.10. PUPIL STEREOTYPE D_{2A}-SIXTH FORM PHYSICS REJECTING, NEUROTIC EXTRAVERTS

This is the group with the highest proportion of girls with 34 of the 70 pupils being female. Although all 70 pupils intend to study A-levels, only one pupil will be studying A-level physics. As many as 63 of the pupils rejecting the subject do so because of an anticipated low grade in a difficult subject. The one pupils choosing the subject did so for exactly the opposite reason. The pupils are attracted by the whole range of career areas with as many as 13 looking towards the sciences, although apparently, not physics.

D_{2A}-type pupils are strongly defined by their personality characteristics. They are neurotic extraverts with very low lie scores. Like type C pupils, they also find the subject very difficult, although general motivation and study habits do not differ significantly from the whole sample norm. Of the teaching method variables, there is less mis-match in the provision of varied, teaching-for-understanding than for any of the other pupil stereotypes apart from Group A,. Even so, physics attitude scores are well below average.

The group, overall, can be described as '<u>physics rejecting, neurotic extraverts</u>'. Teachers will readily identify these pupils from their sixth-form intentions, dislike of physics, personality characteristics and, from check-list item 4, rather low cognitive abilities in physics.

As shown in the cluster B analysis, when physics is disliked, the correlation between the 'nature' and 'comparative image' attitude variables (PHYSID and SAT) tends to be stronger, as the pupils do not discriminate between areas of dislike. D_{2A}-type pupils fall into this category, too. The two attitude scores correlate moderately at 0.35. When the regression equation for variable PHYSID is analysed, academic motivation is seen to be even more strongly associated with physics identification

TABLE 7.11.17. PREDICTOR VARIABLES FOR TYPE D_{2A} STUDENTS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
NEUROT	-0.31	MOT	0.46
PHYSID	0.29	SAT	0.32
Multiple correlation with all cluster variables	0.53	Multiple correlation with all cluster variables	0.64
NEUROT	-0.31		
PHYSID	0.29	MOT	0.49
Multiple correlation with all cluster variables	0.53	Multiple correlation with all cluster variables	0.57

The lower half of the table refers to the regression equation when variable SAT is excluded.

than is comparative subject satisfaction (SAT). Excluding the latter from the analysis (the lower half of table 7.11.17) simply increases the strength of dependence on academic motivation.

Attainment is seen from table 7.11.17 to be allied with emotional stability and good subject attitudes. This relationship is independent of the use of the satisfaction variable.

Factor analysing the continuous variables with an oblique rotation of the factor axes revealed the six recognisable factors of table 7.11.18.

TABLE 7.11.18. FACTORS IN CLUSTER D_{2A}

Factor	Variable	Correlation with factor score	Description
I	MOT	0.91	Motivation. A general factor
(14.8%)	PHYSMOT	0.81	(Section 7.10.5.)
II	VARUND (E)	0.82	A matched teaching-for-understanding
	VARUND (P)	0.73	continuum.
	MATCH	0.59	
(13.0%)	ITS	0.35	
III	PHYSHAB	-0.92	Study habits.
(12.5%)	STUDYHAB	-0.74	A general factor (Section 7.10.5.)
IV	NEUROT	0.90	A personality-attainment factor which
	PERFORM	-0.40	correlates at 0.26 with poor study
(9.5%)	EXTRAV	-0.36	habits.
V	PHYSID	-0.62	A modified 'feeling for physics'
	SAT	-0.49	factor (table 7.11.8.). Subject
	LIE	0.35	antipathy is associated with high
(8.1%)	IMPORT	-0.32	LIE scores.
VI	LBE	0.58	Learning-by-experiment is desired in
(7.0%)	SLOG	0.29	a difficult subject

Variance accounted for by each factor appears in brackets

Subject difficulty and the consequent poor attainment are the major reasons why D_{2A}-type pupils reject A-level physics. The 'difficulty' factor (VI), with its dependence on the pupils desire to learn by experiment, points directly to an area within the control of the teacher which might be expected to minimise the burden of studying this subject (teacher check-list item 7).

As the multiple regression on attainment for these pupils has shown, anxiety is a major 'determinant' of poor academic performance. The factor analysis confirms this deduction and shows that there is a strong association with introversion too. Anxious pupils in cluster A_1, who are apparently more able and taught in a more conducive environment (high MATCH) than are D_{2A}-type pupils were felt to reflect their anxiety by suspect study habits. There is evidence that the D_{2A} pupils in the anxious category demonstrate the same questionable study practices (Factor IV), which makes the teaching of study-skills (teacher check-list, item 5) very relevant to this type of pupil. The appearance of the subject antipathy factor V reflects the pupils' dislike of physics. The association of the major variable on this factor with attainment in the regression analysis demonstrates <u>the importance of improving subject attitudes</u> for D_{2A}-type pupils. The teaching variable factor II measures the preference for and provision of the varied, teaching-for-understanding approach in a matched classroom with an interesting teaching style. However, the lack of any association between the teaching variables and the other factors suggests that the pupils have come to see physics as a clinical, cognitive discipline, independent of the teaching approach, which still holds some allegiance for them at O-level

TABLE 7.11.19. PERFORMANCE IN THE G.C.E. O-LEVEL PHYSICS EXAMINATION

	Number achieving grade					
CLUSTER	A	B	C	D	E	U
A_1	14	40	25	4	4	4
A_2	22	44	37	8	3	2
B	3	19	17	4	3	9
C	0	0	3	4	6	6
D_1	1	8	10	7	8	12
D_{2A}	2	9	29	8	8	12
D_{2B}	5	24	20	9	7	4

Grades A, B and C indicate a 'pass'

because of general academic motivation (table 7.11.17 shows that motivation is the strongest attitude 'predictor'). Success in physics with, as table 7.11.19 shows, so many pupils just achieving the grade C pass, is likely to be due to the less anxious pupils using their inherent cognitive ability and powers of motivation (table 7.11.17).

7.11.11. PUPIL STEREOTYPE D_{2B} - WELL MOTIVATED, PHYSICS 'SLOG' PUPILS

The final group of pupils comprising some 40 boys and 36 girls shows some strong similarities with group A_2, the academically motivated, natural physicists. Referring to table 7.11.3 , they display the same personality characteristics of the stable introvert with the firm code of social behaviour (high LIE scores). In general terms, they show high motivation with good study habits.

However, the scores on the physics variables are inferior when compared with those of the A_2-type pupils, while still being more positive than groups B, C and D_{2A}. Unlike the natural physicists, D_{2B}-type pupils find physics difficult. They are not particularly keen to do well in the subject (low examination and physics motivation), although their attainment and attitudes are average. Responses to all the teaching variables are neutral. While all the pupils intend going on to A-level studies, only 12 will be choosing physics. The most common reason for the choice of A-level physics is career needs. Those rejecting physics do so, for the most part, because of an anticipated low grade in a difficult subject. The second most common group of rejection reasons are those referring to an uninteresting, narrow subject, unattractively taught with insufficient experimental work.

Although 18 pupils state that their career areas lie in science and technology, as many pupils again look for business careers including management and accounting. Significant numbers of pupils are attracted to non-scientific intellectual disciplines and to creative and artistic professions.

There are clear contributions to the regression equations (table 7.11.20). The highest attainment is achieved by pupils holding a favourable 'image' of physics (SAT), and who, rather oddly, find themselves in mis-matched' classrooms.

The negative weighting of the MATCH variable suggests

TABLE 7.11.20. PREDICTOR VARIABLES FOR TYPE D_{2B} STUDENTS

Strongest attainment predictors		Strongest attitude predictors	
Cluster variable	Beta-weight (significant at 5% level)	Cluster variable	Beta-weight (significant at 5% level)
MATCH	-0.33	IMPORT	0.38
SAT	0.26	LIE	0.30
		PHYSHAB	0.29
		ITS	0.27
Multiple correlation with all cluster variables	0.57	Multiple correlation with all cluster variables	0.73

A six-variable regression attainment equation includes significant contributions from VARUND (P) and LBE (negative) in addition to MATCH and SAT. The overall multiple correlation is 0.53.

that pupils getting good grades might be getting a low provision of 'teaching-for-understanding', and are more critical of their classroom environment. These pupils have the confidence to be critical as they are making some progress in a difficult subject. Pupils with poor grades, finding the subject very difficult, and making little progress are less sure of the type of teaching they need (they tend to have low VARUND (P) scores) and, hence, are less critical of what they are offered (high MATCH). Even so, they express a need for learning-by-experiment.

Physics enjoyment and commitment are seen to be most strongly associated with motivation to do well in the examination (IMPORT), an organised code of conventional social behaviour (LIE), good physics study habits and an interesting teaching style.

The academic characteristics of the pupils of this group are not in dispute, the perceived difficulty of physics turns them away. They are 'well motivated, physics slog' pupils.

Factor analysing the continuous variables, excluding VARUND (M), by the principal components method, followed by an oblique rotation of the factor axes, gave eight recognisable factors (table 7.11.21).

TABLE 7.11.21. FACTORS IN CLUSTER D_{2B}

Factor	Variable	Correlation with factor score	Description
I (13.9%)	PHYSMOT MOT	0.92 0.80	Motivation. A general factor. (Section (7.10.5.)
II (12.2%)	PHYSHAB STUDYHAB	0.96 0.80	Study habits. A general factor. (Section 7.10.5.)
III (11.5%)	IMPORT PHYSID	0.72 0.71	'Feeling for physics'. Correlates at 0.30 with 'interesting teacher style'
IV (10.5%)	VARUND (E) VARUND (P) MATCH	0.68 0.64 0.46	Teaching style factor. Measures pupil 'match' on the varied 'teaching-for-understanding' style. A general factor (Section 7. 10.5)
V (7.8%)	PERFORM SLOG	-0.86 0.27	Poor attainment in a difficult subject
VI (6.9%)	EXTRAV NEUROT	-0.72 0.62	Personality factor which measures 'anxious introversion'. Correlates at 0.27 with poor mtoivation
VII (6.4%)	SAT LIE MATCH	0.47 0.41 0.31	Favourable subject image in 'matched' classroom held by socially conforming pupils
VIII (6.2%)	LBE ITS PHYSID	0.55 0.49 0.34	Learning by experiment. Subject enjoyment is enhanced for pupils who see the need for this type of learning (table 7.11.10, factor V).

Variance accounted for by each factor appears in brackets.

The relatively high achieving D_{2B}-type pupils could serve as a pool for future recruitment into the A-level physics population. To accomplish this, it is necessary to lessen the perceived difficulty of the subject (factor V) and to teach it more attractively with more experimental work (the solution suggested for D_1- and C-type pupils). In terms of the regression equations, pupils with high satisfaction scores (rating the subject as modern and exciting) get the best grades but seem to show the highest teaching-methods mis-match. Aiming to minimise this mis-match, by arranging for a greater provision of the VARUND style of teaching for instance, will not on the regression evidence lead to much direct improvement in attainment, but such a step would naturally include more learning-by-experiment, which is itself part of the VARUND methodology. Through factors VII and VIII, subject satisfaction (SAT) and enjoyment/commitment (PHYSID) would be expected to be improved and hence attainment too (table 7.11.20). Further attitude enhancement might be expected from factor VIII, if the teacher is able to match the demands of the VARUND approach convincingly enough to improve the 'interesting teaching style' rating for this pupils group.

Overall, D_{2B}-type pupils contribute no unique items to the practical check-list, but treating these pupils in a similar way to those in the corresponding personality group (cluster A_2) who do choose A-level physics, is likely to cause little harm, and with the additional emphasis above could well result in both D_{2B}- and B-type pupils joining sixth-form physics classes in greater numbers than at present.

7.11.12. THE FINAL CHECK-LIST SUMMARY FOR PHYSICS TEACHERS

The variables and characteristics which have been shown to have significant effect upon attainment and attitudes in physics are summarised in figure 7.11.1. With the exception of the motivation variable, the patterns of behaviour that lead to success are diverse. This confirms the earlier findings of Good et al. (1975) and Good and Power (1976) (Section 1.6.), namely that

a) certain teaching behaviours have differential effects on the various pupil stereotypes in a typical classroom, and

b) the teaching behaviours that maximise achievement are not necessarily those that maximise attitudes.

The regression analyses show that only for A_1 and A_2 pupil types do both the criterion variables of attainment and attitudes show association with similar independent variables, but in each case these are forms of pupil motivation rather than direct teaching behaviour.

The top half of figure 7.11.1 indicates the areas of behaviour and attitudes that are expected to be associated with desirable outcomes at the end of the year, if no correcting action is taken. The lower half of the figure shows the nature of the correcting action to be taken if achievement and attitudes in all groups are to be improved. As pointed out above, different pupil-types require different approaches.

Figure 7.11.1 THE SUMMARY TEACHING PLAN

		PUPIL TYPE						
		Anxious physicists sympa-thetically taught A_1	Academi-cally motivated, natural physicists A_2	Severely mis-matched pupils B	'Good-time', poor achieving extraverts C	Well-adjusted, poor achieving leavers D_1	Sixth-form physics rejecting, neurotic extraverts D_{2A}	Well-motivated physics 'slog' pupils D_{2B}
Variable or characteristic shown to be significantly associated with high attainment or good attitudes	Study skills							
	Need for varied teaching-for-understanding							
	Motivation							
	Physics enjoyment/ commitment				Negative with attainment	Positive with attainment	Positive with attainment	
	Personality type	Neurotic intro-version			Extra-version		Stable extra-version	Social-value oriented
	Subject image and/or teaching style							
	Finding the subject easy							
	Matched classroom environment							
Prior knowledge needed to identify pupil-type	Assess cognitive ability	High	High		Low	Low		
	Recognise personality type	High anxiety	Stable introverts		Extraverts	High stability	Neurotic extraverts	Stable introverts
Suggested procedures requiring a possible change in practice	'Matched' classroom environment							
	Flexible classroom organisation							
	Study skills to be taught							
	Varied, teach-ing-for-under-standing to be extended							
	Learning by experiment to be extended							
	Subject image and teaching style							

An attempt was made in the preceding Sections to develop a check list of physics teaching activities. The inevitable overlap of these activities across several of the pupil clusters, and the likely occurrence of most, if not all, the pupil stereotypes within one physics class, means that the check-list should be more properly applied to the class as a whole. The list then becomes:

a) Item 1 - pupil personality

This is a prior knowledge variable (figure 7.11.1 and Appendix 7.11.4). The formal administration of the Eysenck Inventory is not essential. Teachers would be expected to be familiar with the extreme poles of the two major personality factors of extraversion and neuroticism (anxiety). It is reasonable to expect teachers who have taught their pupils for two or more years, say, to be able to rate them sufficiently reliably for classification into one of the seven stereotypes of figure 7.11.1. It is even possible to use a highly abbreviated form of the Eysenck Inventory to obtain the pupils' own ratings of their personalities (Pell, 1980).

b) Item 2 - pupil cognitive ability in physics

This is the second prior knowledge variable and is available from the teacher's own cognitive tests.

c) Item 3 - pupil intentions after the fifth-form examination

Together with items 1 and 2, the teacher should now have sufficient information to complete the classification of pupils into stereotype groups, as far as this is possible. The nature of human behaviour and of the cluster analysis procedure itself (Youngman, 1975) is such that some pupils will occupy peripheral positions within the clusters and be difficult to identify.

d) Item 4 - pupil motivation

While information on motivation both in general and in physics can confirm pupil classification, the need for a teacher to be aware of and, as far as it is possible, to improve his pupils' academic motivation is clear from the demonstrated impact of this variable on desirable attitudes and attainment (figure 7.11.1). Assessing motivation requires either the subjective experience of a teacher well acquainted with his pupils (Section 5.3.5) or the use of the modified Rowntree scales of Section 5.3.

e) Item 5 - pupil study skills

Only for the well motivated, physics 'slog' pupils are study habits significantly related to classroom outcomes, but for several pupil-types instruction to improve these skills has been suggested. It might be necessary to tackle this problem on an individual or small group basis once areas of deficiency (revealed by the modified Rowntree scales) have been identified.

f) Item 6 - matched learning environment

Significant areas of mis-match can arise with some pupil types. It is important that the teacher knows which of his pupils are in a mis-match environment. The use of the questionnaire scale of Section 5.4 is appropriate.

g) Item 7 - learning-by-experiment

This is a key variable in improving the quality of learning in physics classes, being related (in theoretical terms) to finding the subject easier and the varied, teaching-for-understanding method. A decrease in examination syllabus content (Section 7.5.6) would encourage more teachers to use this approach more extensively.

h) Item 8 - varied, teaching-for-understanding

This teaching methodology is defined in Section 5.4 and analysed in Section 7.4. Although it has been shown to have a direct effect on classroom outcomes for D_{2B}-type pupils only, it is an effective practical way of relating items 6 and 7 in a unified approach to class teaching. Overall, this method is associated with pupil enjoyment for both boys and girls (Section 7.4.3).

i) Item 9 - flexible classroom teaching

Two pupil-types do not appear amenable to unified class teaching. The teacher should consider how the classroom activities could be structured to permit this (see below).

j) Item 10 - subject image/interesting teaching style

Satisfaction with physics, a comparative subject attitude, and finding the teacher's style in the classroom interesting often are related in establishing an environment conducive to effective learning. The satisfaction scale is defined in Section 5.5.3, and draws upon the feeling that physics is exciting, modern and of high prestige. This should encourage the teacher to emphasise these aspects of the subject, which is readily permitted within the varied approach of item 8.

7.11.13 SOME SPECIFIC PROBLEMS

Once the teacher has identified the stereotype composition of his class and monitored attitude and preference areas, he is then in a position to plan his teaching to maximise outcomes for as many pupils as possible. In doing this, the evidence from Sections 7.11.5 to 7.11.11 is used as appropriate. The most common problems and possible solutions appear below.

1. Teaching the physics specialist pupils

The methods used to teach pupils of types A_1 and A_2 in the survey schools were generally well matched to the pupils needs and specifically directed towards the varied, teaching-for-understanding style. The highly anxious pupils tend to be attitude- and teaching -style-oriented towards academic success whereas the stable introverts are more ability oriented.

A_2-type pupils will succeed because of their high ability,but attitudes can be further improved by expanding an awareness of the nature of physics by including more learning-by-experiment within the teaching-for-understanding style. A_2-type pupils, the stable introverts, will be capable of more independent work. A_1-type pupils show high anxiety: they will need more support with learning-by-experiment in the homogeneous teaching of 'core' material in the typical physics class. The variety of the teacher's presentation will have an all-round benefit on the A_1-type pupils. Teaching study skills to both pupil types might not directly influence physics attainment or attitudes, yet is difficult to deny on educational grounds, and for the uncertain pupils of type A_1 this extra structure might be welcomed as a perception of the teacher's 'interesting style' and also enhance all- round motivation.

2. Eliminating the mis-match in group B

Teaching type B pupils in a similar way to types A_1 and A_2 with emphasis on a varied presentation of lesson material in the 'understanding' format will largely elimiante this group. The classroom needs are similar to those of type A_1 pupils and, in addition, the positive instruction in study techniques would be expected to lessen subject difficulty. Attainment of type-B pupils is well above average, even when they are poorly taught, so an improvement in attitudes could increase the A-level physics take-up rate.

3. <u>Teaching a class containing a significant proportion of pupil- types C and D_1</u>

Because of the difficulty in accommodating the needs of pupils of types C and D_1 in conventional homogeneous classes, it has been suggested that some form of flexible classroom organisation is needed.

A substantial commitment to learning-by-experiment with the mastery of lower order thinking skills in a matched classroom environment is highly desirable. Some achievement and subject mastery would then be expected to improve motivation and a liking for the subject. It would be naive to expect an improvement to the highest attainment and motivation levels but, at the very least, the pupils would acquire some sense of achievement and other pupil-types in the class suffer less disturbance from the sometimes vociferous demands of their peers.

The teacher must be clear of the expressed needs of the C- and D_1-type pupils for an ideal classroom match. Not that this preference alone should determine their treatment, but a structure should be built into the classroom organisation so that, if necessary, these pupils work on a specific syllabus or assessment option, which is likely to become common as the new '16+' examination is developed. Part of the teacher's time each lesson would be spent guiding this particular group whilst their classmates were occupied on other tasks, and vice-versa. The class as a whole would retain its coherence for certain core activities, such as teacher-demonstrations and examination preparation.

Rather large proportions of C- and D_1-type pupils take the C.S.E. examination in the survey classes, so that the stratified classroom organisation may have been partially, but unsuccessfully, adopted already. D_1-type pupils who make up the category responding favourably to the teaching-for-understanding style could well be grouped together in the stratified classroom so that they might be deliberately exposed to this method.

4. Making physics easier for type D_{2A} pupils

The block of subject difficulty for these pupils turns them away from physics in the sixth-form. Motivation towards academic subjects determines attitudes to physics and these attitudes, together with low anxiety levels, are associated with eventual attainment. The classroom environment should be so prepared for these students that their anxiety is reduced by structuring their learning to give a stability to which they might continually refer. For instance, the teaching of study skills would be most appropriate, as would guided learning-by-experiment. The latter would resemble the approach recommended for type A_1 pupils, rather than a slightly more open-ended 'nature of physics' approach that would be envisaged under some circumstances (for example, extra homework problems) for the more able 'natural' physicists of type A_2.

There is no evidence that classroom match or exposure to the varied,teaching-for-understanding approach affects the outcomes of attainment and attitudes one way or the other. In a heterogeneous class, teaching-for-understanding will be adopted for the majority of pupils of the other groups so no adverse reaction would be expected from type D_{2A} pupils.

5. Recruiting A-level physics students from type D_{2B} pupils

Type D_{2B} pupils are the stable introvert cousins of type A_2 with similar academic aspirations, although more likely than not, these do not include physics, which is felt to be too difficult and unattractive. The teaching method is significant: learning-by-experiment within the teaching-for-understanding format, which is pursued by a teacher leading in an enthusiastic and interesting manner, are all likely to contribute towards improved attitudes and attainment. As there is a direct association between attitudes and good study methods, the provision of some teaching of study skills for the other pupil-types would yield a benefit with D_{2B} pupils, too.

7.11.14. MULTIPLE CORRELATIONS BEFORE AND AFTER CLUSTERING

Table 7.11.22 summarises the strengths of the overall criterion correlations for all the clusters.

The refinement brought about by the clustering technique is clearly demonstrated. The gross correlations for the whole sample are seen to hide a fine structure of differential multiple associations, which have appeared in earlier regression tables.

TABLE 7.11.22. SUMMARY TABLE FOR THE SEVEN PUPIL CLUSTERS

Pupil cluster		Multiple correlations for PERFORM	Multiple correlations for PHYSID	Correlation between PERFORM and PHYSID
A_1	Anxious physicists, sympathetically taught	0.64	0.58	0.04 NS
A_2	Well motivated, natural physicists	0.53	0.61	0.12 NS
B	Moderate achievers, highly mis-matched	0.52	0.63	0.03 NS
C	'Good-time', poor achieving extraverts	0.45	0.72	-0.22 NS
D_1	Well adjusted, poor achievers	0.52	0.70	0.31
D_{2A}	Sixth-form physics rejecting, neurotic extraverts	0.53	0.64	0.26*
D_{2B}	Well motivated, physics 'slog' pupils	0.57	0.73	-0.08 NS
Combined sample, before clustering		0.50	0.74	0.30

All correlations are significantly different from zero at the 1% level except *$p < 5\%$: NS not significant

Achievement (PERFORM) is better predicted within the cluster structure but enjoyment/commitment (PHYSID) tends to be predicted slightly less well.

7.11.15. PUPIL-TYPES AND CLASS-TYPES

In Section 7.9, six types of fifth-form class were identified (table 7.11.23).

TABLE 7.11.23. CLASS TYPES

	Description of physics class	Number of classes of this type
A	Highly motivated, book-learning	10
B	Teacher centred, neutral	9
C	Well intentioned, mis-match	5
D	Anxious, high drive for success	5
E	Expository, pragmatic teaching of neutral science	3
F	Optimum outcome classes	4

By using the two classification of pupil-type and class-type it is possible to allocate each of the 547 pupils to one of the 42 possible cells of table 7.11.24. Such a procedure inevitably results in some low cell membership numbers.

Tables 7.11.25 and 7.11.26 attempt to explore cell differences in terms of pupil mean scores on the attainment (PERFORM) and attitude (PHYSID) variables.

TABLE 7.11.24. THE SIZES OF THE CLASS-TYPE /PUPIL-TYPE SUB-GROUPS

Class-type	A_1	A_2	B	C	D_1	D_{2A}	D_{2B}
A	21	44	20	9	23	19	30
B	22	34	10	9	23	23	20
C	1	10	19	25	6	2	5
D	16	11	8	13	6	16	5
E	17	11	8	6	5	8	7
F	7	8	0	0	0	1	8

TABLE 7.11.25 PHYSICS ATTAINMENT ACCORDING TO PUPIL AND CLASS TYPE

	Pupil-type mean scores on PERFORM scale						
Class-type	A_1	A_2	B	C	D_1	D_{2A}	D_{2B}
A	4.52	4.57	4.00	3.78	3.52	3.89	4.10
	(1.29)	(1.26)	(1.49)	(0.97)	(1.44)	(1.24)	(1.47)
B	3.77	4.29	3.50	2.89	2.61	3.52	4.25
	(1.31)	(1.09)	(1.65)	(1.36)	(1.47)	(1.27)	(1.25)
C	4.00	4.70	3.58	2.52	3.17	4.00	3.40
	(0)	(1.25)	(1.50)	(0.82)	(1.72)	(0)	(1.34)
D	4.56	4.82	4.00	2.54	3.00	2.50	3.80
	(1.41)	(0.75)	(1.51)	(1.13)	(1.67)	(1.37)	(0.84)
E	4.94	4.82	4.00	2.33	4.00	3.12	3.43
	(0.83)	(0.60)	(1.60)	(1.21)	(1.00)	(1.55)	(1.72)
F	4.43	4.75				4.00	3.87
	(0.53)	(0.71)				(0)	(0.64)
One way analysis of variance test	NS	NS	NS	<5%	NS	NS	NS

Standard deviations appear in brackets

NS denotes no significant differences between the means for that pupil-type.

TABLE 7.11.26. PHYSICS ENJOYMENT ACCORDING TO PUPIL AND CLASS TYPE

	Pupil-type mean score on PHYSID scale						
Class-type	A_1	A_2	B	C	D_1	D_{2A}	D_{2B}
A	66.71	75.11	59.95	49.44	64.61	57.42	63.03
	(8.46)	(9.10)	(8.23)	(8.82)	(10.90)	(6.86)	(9.22)
B	68.36	74.38	65.20	54.33	62.00	59.43	58.60
	(10.60)	(7.34)	(11.48)	(10.07)	(9.47)	(6.82)	(9.26)
C	81.00	76.80	54.26	46.12	63.83	59.50	69.20
	(0)	(10.97)	(8.61)	(12.30)	(6.71)	(12.02)	(10.99)
D	69.25	78.91	60.75	53.15	62.83	59.06	58.20
	(6.62)	(10.74)	(10.18)	(11.43)	(15.20)	(8.42)	(8.07)
E	69.29	72.54	65.88	45.67	60.00	58.75	69.14
	(8.84)	(7.89)	(16.35)	(6.28)	(15.70)	(9.32)	(11.25)
F	72.86	78.88				67.00	65.88
	(12.38)	(10.75)				(0)	(13.04)
One way analysis of variance test	NS	NS	<5%	NS	NS	NS	NS

Standard deviations appear in brackets
NS denotes no significant differences between the means for that pupil-type.

In table 7.11.25, the application of a one-way anaysis of variance test shows that only for type C pupils is there a significant interaction with class-type. Apparently, these pupils of poor academic motivation and the extraverted personality show the highest achievement in the strongly academic environment of 'book-learning' physics classes. As table 7.11.24 shows, these pupils are likely to be very much in the minority in such classes, and it is possible that the peculiar pressures of these classes on such pupils is to enhance their performance, although enjoyment is hardly improved (table 7.11.26).

With the exception of type C pupils, table 7.11.25 shows that attainment for any one group of pupils tends to be independent of the type of class.

Table 7.11.26 shows that physics enjoyment/commitment, similarly, tends to be independent of the pupil-type/class-type interaction. The one significant exception is demonstrated by the moderate achieving but highly 'mis-matched' pupils of group B. It will be recalled that these pupils strongly demand the varied, teaching-for-understanding style. The evidence from table 7.11.26 is that when such pupils are in type C classes, where the teacher is unable to translate his knowledge of the most effective learning environment into real classroom activities and so frustrates the pupils' needs, then this type of pupil displays particularly poor attitudes.

7.11.16. DISCRIMINATING BETWEEN PUPIL-TYPES

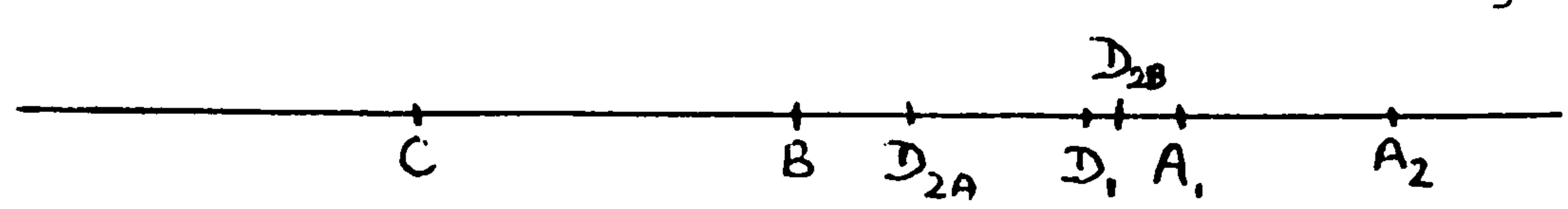
Discriminant function analysis was used with the continuous variables, excluding VARUND (M), in an attempt to identify one strong function which might effectively discriminate between the pupil clusters. The S.P.S.S. 'Discriminant' procedure revealed that even with a maximum of six orthogonal discriminant functions it is possible to classify only 76.4% of the pupils correctly. As Appendix 7.11.6 shows, it is relatively easy to classify pupils of type B but much more difficult with those of type D_1.

The most important discriminant function, accounting for over half the variance in the seventeen discriminating variables, measures the amount of varied, teaching-for-understanding received by well motivated pupils with good study habits in physics, who give the subject a high'image' rating (SAT) in classes well matched to pupils' preferences. This major discriminating function describes a '<u>well-taught, highly motivated</u>' dimension. Pupil-types A_2 and C occupy the opposite poles of the discriminating continuum (figure 7.11.2). However, this single function can classify correctly only 43.2% of the pupils, mostly those of types A_2 and C.

FIGURE 7.11.2. DISTRIBUTION OF PUPIL-TYPES ALONG THE FUNCTION CONTINUUM (MEAN SCORES)

Low VARUND (E)
Low motivation

High VARUND (E)
High motivation



Although the discriminant analysis confirms the appropriateness of the research variables in distinguishing between pupil-types, it adds little to sharpen the differences between the pupil clusters.

7.11.17. CONCLUDING REMARKS

An achievement of the research reported in this Section is the sharp identification of seven pupil stereotypes in fifth-form physics classrooms. Although paths to be followed for successful outcomes with each stereotype have been shown to be different, certain key teaching behaviours, namely

a) the creation of a learning environment matched to pupil preferences;

b) the use of a varied, teaching-for-understanding method, which is a teaching approach intermediate between the pupil oriented/'discovery' method and the strongly teacher-centred expository method, and which permits learning-by-experiment;

c) the teaching of study skills, and

d) strong teacher support for anxious pupils,

all contribute towards a classroom structure which is compatible with successful outcomes for five of the seven stereotypes. (The strongest 'predictor' for achievement however, is generally the pupil's own academic achievement or examination motivation). At any one time and in any one class, the five stereotypes might be in need of five variations of teacher support, but such is the relative homogenity of needs and solutions that the teacher might reasonably be expected to move comfortably from one situation to another with subtle changes in question style and lesson presentation.

The strength of the particular teaching model that has been developed here for the pupil majority is shown by referring back to Good and Power's work in Australia. They conclude that:

> '... only teachers who include a variety of instructional modes in their instructional programme will be able to optimise the achievement of the class as a whole (while creating an environment that holds reasonable satisfaction for each type of student).'
>
> (op.cit., p.57)

Good and Power point out that in the typical classroom a 'trade-off' has to take place between the competing needs of the pupil-groups. Suggesting that such a trade-off should occur between the relatively homogeneous mix of the five stereotypes and pupil types C and D_1 is questionable. These last two poor achieving groups need carefully structured classrooms heavily oriented towards concrete learning. As they would comprise minority groupings in conventional classes, their lack of success might be partly due to their neglect at the expense of the more able pupils. Good and Power refer to 'phantom' pupils who are rarely heard or seen (!), never volunteer, never create problems and display average attitudes. Such 'phantoms' could exist within pupil-type D_1 and, in a conventional seven stereotype class, their anonymity would be assured. However, if pupil numbers warrant it, separate classes for these poor achievers aimed at a less demanding end-of-course assessment is recommended. This report has suggested the form of structure the type C- and D_1-type pupils need. As these two groups are the least easily accommodated in the conventional class 'unit', opportunities should be looked for in computer-assisted learning to aid group project work and individual techniques. If C- and D_1-type pupils are present in conventional classes in small numbers, some form of partial, individualised work scheme would be better than allowing the peculiar problems of these students to continue unchecked.

It is regrettable that the overall sample size was insufficient to allow for greater cell frequencies in the class-type/pupil-type interaction, but given the inevitable difficulty in collecting a full set of data in a longitudinal study, a sample of 1500 to 2000 pupils would be necessary in a sponsored project.

7.12. THE HIGH LIE SCORERS

7.12.1. HIGH SCORES ON THE EYSENCK LIE SCALE

The use of the Eysenck personality scales has been reported in Section 7.3. The Lie scale of nine items included within the ineventory was intended, originally, to measure faking of responses (Eysenck and Eysenck, 1964), but as evidence has been collected on the use of this scale (Section 7.3.3., Eysenck and Eysenck, 1976) it has become clearer that it is measuring two dimensions. The first is a propensity to lie and second is a distinct personality characteristic of conformity to a conventional code of social behaviour.

If some pupils are faking responses, the key criteria are (a) lie scores of five or more, (b) low scores on the neuroticism scale (Eysenck and Eysenck, 1964) and high scores on other survey variables consistent with a propensity to lie (e.g. study habits and physics enjoyment). To try to isolate the two dimensions of the lie scale, cluster analysis runs were performed on various sub-sets of the fifth-form variables of table 5.1.1.

7.12.2. THE PERSONALITY AND STUDY-ORIENTATION ANALYSIS

Study orientation and personality variables (Section 7.3) were used together with G.C.E./C.S.E. examination performance and the dichotomous variables of sex and form of examination assessment. The total sample size was 677 pupils. Two cluster analysis runs using Youngman's P.M.M.D. program gave three stable high lie scoring clusters which were independent of the data input order to the program. Table 7.12.1 shows the standardised mean scores for just these three clusters, X,Y and Z.

TABLE 7.12.1. THREE HIGH LIE SCORING CLUSTERS

	Cluster mean score (standardised)		
Variable	X (N = 46)	Y (N = 41)	Z (N = 42)
SEX	-0.51**	1.66**	-0.60**
STUDYHAB	0.45*	1.07**	1.20**
MOT	0.28	0.49*	0.86**
PHYSHAB	0.46*	1.04**	1.31**
PHYSMOT	0.43	0.32	0.86**
EXTRAV	0.60**	-0.75**	-1.13**
NEUROT	-0.77**	-0.02	-0.11
LIE	0.67**	0.93**	1.10**
EXAM	-0.52**	-0.52**	-0.41**
PERFORM	-1.03**	0.55	0.76**

** $p < 1\%$; * $p < 5\%$ (between cluster mean and mean of remaining scores)

The scores on the sex variable indicate that group Y is entirely female; group Z is entirely male, and group X is strongly male with just two girls. The EXAM variable shows that the pupils in all three groups are almost exclusively G.C.E. O-level entrants in physics.

In so far as the combination of 'high lie/low neuroticism' is a valid criterion for identifying a specific 'lie' group, the pupils of cluster X are seen to be candidates for such a category. Although the other two clusters, Y and Z, have even higher mean scores on the Lie scale, their neuroticism scores are unremarkable.

Some confirmation of the suspected nature of cluster X is given by the attainment scores on variable PERFORM. Only one of the total number of 15 cluster mean scores is lower than that achieved by cluster X.

It has been shown in Section 5.3.4 that there is a significant correlation between study habits in physics and attainment. While groups Y and Z apparently confirm this, it is noteworthy that group X do not. It is tempting to suggest that some of the pupils of group X are faking their responses to the study habits scale. On the other hand, group X are highly extraverted and when there is a significant relation between personality and attainment, it is usual for extraversion to be associated with poor performance at this academic level (as illustrated in table 7.11.7, for instance). Thus, the poor achievement of group X might be more a function of their extraversion trait rather than a propensity to lie (as measured by inflated study habits scores).

The mean raw lie score for group X, although relatively high in relation to the sample mean as a whole, is only 3.93. This implies that high lie scorers (some 19 pupils have scores of five or more) comprise just a small segment of this cluster. A further investigation using the personality and study methods variables alone proved inconclusive.

7.12.3. AN ALTERNATIVE APPROACH

An alternative approach to try to isolate the high lie, 'faking' pupils involved clustering the scores of all the fifth-form variables of table 7.11.3, including the attainment and attitudes to physics (PHYSID) variables. This procedure was expected to reveal one or more high lie scoring pupil groups according to the criteria of Section 7.12.1 having the advantage over the personality clustering of a wider range of variables.

An inspection of table 7.11.3 shows that pupil group D_{2B} has some of the characteristics being looked for – high lie scores, low neuroticism scores and good study habits. However, the modest attainment of group D_{2B} as a whole, possibly responding to the strong influence of the subject difficulty variable, suggests that if this group does contain a number of 'faking' pupils inflating their attitude scores, then these would be very much in the minority.

When the cluster analysis was re-run, a stable group of some 33 pupils with high lie, low neuroticism, high study habits, high motivation and low attainment scores was identified. Of the 33 pupils, 27 were of 'type' D_{2B}. Inspecting the raw lie scores, and rejecting those of four or less, left a possible 'faking' group of 14 pupils containing 11 from group D_{2B}. Table 7.12.2 describes the characteristics of this group.

It is clear that variables which have easily determined, desirable response categories show significantly higher scores in almost all instances. Thus, possible 'fakers' rate the physics teacher's style (ITS) as particularly interesting; they have very desirable study methods

TABLE 7.12.2. THE POSSIBLE 'FAKING'GROUP

Variable	Raw mean scores (Standard deviation)			
	Possible 'fakers' (N = 14)		All others (N = 533)	
PERFORM	3.57	(1.28)	3.81	(1.45)
PHYSID	74.14	(4.99)	63.79	(12.50)**
STUDYHAB	6.57	(1.45)	5.05	(2.25)**
MOT	11.86	(1.23)	10.35	(2.65)**
EXTRAV	9.21	(4.41)	13.16	(4.26)**
NEUROT	8.07	(2.84)	10.81	(4.16)*
LIE	6.00	(1.04)	2.72	(1.64)**
LBE	23.57	(3.08)	21.78	(3.68)
ITS	3.86	(0.86)	3.11	(0.94)**
PHYSHAB	6.36	(1.55)	5.28	(2.49)
PHYSMOT	12.19	(1.54)	10.88	(3.26)**
VARUND (P)	26.29	(2.49)	25.75	(2.62)
VARUND (E)	22.86	(3.21)	22.05	(3.76)
VARUND (M)	3.43	(3.44)	3.70	(3.87)
MATCH	10.79	(2.75)	9.72	(3.52)
SAT	9.21	(1.93)	9.63	(2.11)
SLOG	5.00	(0.96)	4.33	(1.31)
IMPORT	3.07	(0.48)	3.11	(0.74)
EXAM	12 G.C.E. :	2 C.S.E.	442 G.C.E. :	91 C.S.E.
SEX	11 boys :	3 girls	390 boys :	143 girls
ALEVEL	13 choose :	1 reject	429 choose :	104 reject
PHYSCHOICE	1 choose :	13 reject	229 choose :	304 reject**

**p < 1%; * p < 5% (t-test)

The four dichotomous variables, SEX, ALEVEL, PHYSCHOICE and EXAM were tested for significance by means of the χ^2-statistic.

and show strong motivation (the physics study habits variable only just ceases to reach significance at the 5% level), while holding very positive attitudes towards the subject (although only one pupil intends to study it at A-level).

Variables which measure less obviously 'correct' attitudes, such as those relating to the classroom teaching environment, draw quite unremarkable responses.

When the 11 group D_{2B} 'fakers' are compared with the remaining pupils of group D_{2B} (table 7.12.3), their separate identity is demonstrated by their very high scores in the key 'faking' variables of teacher style and subject attitude (PHYSID). Indeed, the attitudes of this possible 'faking' group of pupils compare favourably with those of the two major A-level physics choosing groups A_1 and A_2 (table 7.11.7). However, attainment is worse, which might appear to confirm a 'faking' hypothesis, such as

> 'desirable attitudes are revealed from questionnaire responses in order to please and to give a good impression: in reality, as measured by attainment in the examinations and A-level physics take-up rate, these attitudes are suspect.'

Further analysis questions this interpretation. Group D_{2B} pupils (including the possible 'fakers') comprise those who find the subject difficult, despite other meritorious academic attributes, and who reject it for this reason. To accept the 'faking' hypothesis, it is also necessary

TABLE 7.12.3. THE 'FAKERS' IN GROUP D_{2B}

Variable	Raw mean scores (Standard deviation)					
	Possible 'fakers' (N = 11)			Others (N = 65)		
PERFORM	3.45		(1.37)	4.08		(1.29)
PHYSID	75.36		(4.78)	60.85		(9.44)**
STUDYHAB	6.91		(1.30)	6.77		(1.53)
MOT	11.82		(1.33)	11.42		(2.05)
EXTRAV	9.27		(4.69)	10.97		(4.32)
NEUROT	8.73		(2.83)	9.19		(3.64)
LIE	6.00		(0.89)	3.91		(1.61)**
LBE	23.09		(3.15)	21.00		(4.32)
ITS	3.91		(0.94)	3.25		(0.75)*
PHYSHAB	6.64		(1.50)	6.79		(1.71)
PHYSMOT	12.27		(1.62)	11.34		(2.75)
VARUND (P)	26.55		(2.77)	25.89		(2.27)
VARUND (E)	22.91		(3.62)	22.79		(2.61)
varund 8m9	3.64		(3.88)	3.10		(2.68)
MATCH	10.73		(2.68)	9.92		(3.06)
SAT	8.64		(1.69)	8.80		(1.94)
SLOG	5.18		(0.75)	4.92		(1.15)
IMPORT	3.18		(0.41)	2.83		(0.55)*
EXAM	9 G.C.E.	:	2 C.S.E.	60 G.C.E.	:	5 C.S.E.
SEX	8 boys	:	3 girls	32 boys	:	33 girls
ALEVEL	11 choose	:	0 reject	65 choose	:	0 reject
PHYSCHOICE	0 choose	:	11 reject	2 choose	:	64 reject

**p < 1%; * p < 5% (t-test)

The four dichotomous variables, SEX, ALEVEL, PHSYCHOICE and EXAM were tested for significance by means of the χ^2-statistic to accept that pupils who find physics difficult inevitably display poor enjoyment and commitment (PHYSID). Table 7.12.4 gives the simple correlations between the difficulty and attitude (PHYSID) variables for the various pupil groups.

TABLE 7.12.4. CORRELATION BETWEEN SUBJECT DIFFICULTY AND IDENTIFICATION

Pupil cluster	N	Simple correlation between SLOG and PHYSID
A_1	86	-0.11
A_2	120	-0.11
B	65	-0.24*
C	64	-0.09
D_1	66	-0.47**
D_{2A}	70	0.17
D_{2B}	76	0.00
All	547	-0.38**

**p < 1%, * p < 5%

Overall, it is seen that difficulty is associated with poor subject attitudes, but the breakdown by cluster type shows that this is not always the case. For some pupil sub-clusters it is likely that favourable attitudes accompany perceived subject difficulty. Thus, the 'faking' hypothesis is questioned: it appears that <u>it is possible for some pupils to like physics while still finding it difficult</u>.

The breakdown of subject identification by subject difficulty, as it appears in table 7.12.5 , confirms that for most of the pupil clusters, pupils who find physics difficult are just as likely to enjoy and identify with the subject as they are to dislike and reject it.

The two clusters which display significant

TABLE 7.12.5

SUBJECT IDENTIFICATION SCORE BROKEN DOWN BY SUBJECT DIFFICULTY

Pupil Cluster	SLOG = 2		SLOG = 3		SLOG = 4		SLOG = 5		SLOG = 6	
	PHYSID	N	PHYSID	N	PHYSID	N	PHYSID	N	PHYSID	N
A_1	71.85 (8.74)	13	66.74 (9.64)	19	69.83 (9.53)	29	68.44 (9.53)	9	66.88 (6.68)	16
A_2	76.68 (8.67)	37	74.60 (8.44)	35	76.04 (9.05)	29	72.89 (11.43)	9	73.20 (8.50)	10
B *	71.57 (14.62)	7	58.89 (8.27)	9	57.33 (11.56)	18	65.40 (7.40)	5	57.89 (8.77)	26
C	-	0	31.00 (0)	1	51.94 (11.14)	18	51.43 (6.35)	7	48.11 (11.26)	38
D_1 **	69.43 (9.69)	7	69.93 (11.06)	14	61.48 (8.32)	25	67.00 (1.41)	2	56.00 (9.41)	18
D_{2A}	-	0	54.17 (8.13)	6	58.05 (7.77)	20	60.71 (10.55)	7	59.49 (6.48)	37
D_{2B}	74.00 (8.49)	2	54.00 (7.45)	5	64.25 (10.67)	20	62.50 (12.74)	16	63.06 (8.54)	33
All **	74.33 (9.74)	66	67.57 (11.98)	89	64.03 (12.24)	159	63.96 (11.76)	55	58.57 (11.02)	178

Standard deviations are shown in brackets

Differences between groups, when tested by a one-way analysis of variance, are significant as indicated (*p < 5%, ** p < 1%)

associations between subject difficulty and poor attitudes; namely, 'severely mis-matched pupils' (Cluster B) and 'well adjusted, poor achieving leavers' (Cluster D_1), are clearly special cases. Their characteristics have been described in Sections 7.11.7 and 7.11.9.

In conclusion, although a possible 'faking' group has been isolated, there is no unequivocal evidence that these pupils were faking their questionnaire responses. This group might simply comprise well motivated pupils with above average subject attitudes, who find the subject difficult enough to depress examination attainment. The high lie scores are just as likely to be a measure of social conformity for these stable introverts as they are to be a measure of faking of responses.

7.12.4. CLUSTERING HIGH LIE SCORERS

A final attempt to demonstrate unequivocally the existence of a 'faking' group by repeating the cluster analysis of Section 7.12.3 for pupils with lie scores of 5 or more proved abortive. Up to four stable clusters appeared, but these were unremarkable, namely:

i) A-level physics choosers with good attitudes, motivation and study methods (N = 31).

ii) A-level physics rejectors who find the subject difficult (N = 33).

iii) Pupils with poor attitudes, motivation and study methods in high mis-match classes (N = 14).

iv) Leavers with moderate attitudes and motivation but poor achievement (N = 12).

There is no trace of a 'faking' cluster with 'good' attitudes and motivation accompanying poor achievement and low anxiety scores. Even so, the analysis is able to confirm the continuous nature of the Lie scale. Above a scale score of 5, meaningful psychological groupings are readily obtained. The application of the Eysenck cut-off criterion, as illustrated by the table in Appendix 7.12.1 , removes, for the most part, stable introverted pupils with desirable academic characteristics.

7.12.5. CONCLUDING REMARKS

The conclusions from this extended analysis must be:

a) that no more than 14 of 547 pupils were faking (some of) their questionnaire responses, but that the true proportion could well be even less than this;

b) that Eysenck Lie scores of 5 or above are more likely to be a measure of a quality associated with the characteristics of stable introverts rather than a propensity to lie;

c) that further analytical research is required by psychologists to develop a valid LIE scale for use with restricted test instruments but that, in multivariate research designs, the technique of cluster analysis could be employed to check the degree to which responses are faked.

The nature of the survey design and the statistical analyses did not permit the possible faking pupils to be followed up with an interview to ascertain the validity of the Lie scale. It is recommended that future multivariate research designs, which employ the Eysenck Personality Inventory, include this validity check after a cluster analysis of the research data.

Until a valid Lie scale is available, in surveys such as the present one where there is no real motivation to fake responses, there seems insufficient justification for omitting data from pupils just because their lie scores exceed the 'cut-off' value, despite the confirmation of the 'Eysenck criterion' of negative lie score/neuroticism association from Section 7.3.3 (also see Appendix 7.12.2). Consequently, all analyses in the present report use all relevant data from all pupils, as appropriate.

7.13. TESTING THE HYPOTHESES FOR THE FIFTH-FORM PUPILS

The evidence collected in this Chapter and in Chapter 5 allow the hypotheses of Section 3.2. to be tested.

Hypothesis 3.2(a)

Fifth-form physics pupils find physics more difficult than other subjects

This is retained for both boys and girls (Section 7.5.6). In addition, for A-level physics choosers, physics is rated either the most difficult subject (girls) or second most difficult subject (boys).

Hypothesis 3.2(b)

Fifth-form physics pupils find physics less interesting than other subjects

This hypothesis is rejected for both boys and girls on the evidence of table 7.5.1. For boys, physics is one of the two most interesting subjects, and, although it is much less liked by the girls, it does not stand alone. Amongst A-level physics choosers, the subject is rated either first or second in interest (table 7.5.8).

Hypothesis 3.2(c)

Fifth-form physics pupils prefer to learn in a varied environment where experiences include verbal, experimental and multi-media learning techniques provided under a strong teacher guidance element

The identification of a specific factor describing this varied learning style defined by the items of table 5.4.6 , and compared with other aspects of classroom management (figure 5.4.1 and table 7.4.1), causes this hypothesis to be retained for both boys and girls. By establishing a reliable varied, teaching-for-understanding scale, this research has permitted a more expansive interpretation of this hypothesis.

Girls show an even greater preference for varied, teaching-for-understanding.

Hypothesis 3.2(d)

Fifth-form physics pupils, if stable introverts, have the best study habits

This hypothesis is retained for both boys and girls on the evidence of tables 7.3.2 and 7.3.3.

Hypothesis 3.2(e)

Fifth-form physics pupils, if stable introverts, have the highest academic motivation

On the evidence of tables 7.3.2 and 7.3.3., this hypothesis is rejected for both boys and girls. Academic motivation is unrelated to stability or anxiety for either sex. There is a weak relation with introversion for boys.

Hypothesis 3.2(f)

Fifth-form physics pupils, who have the highest achievement as measured by the G.C.E. O-level grade,

(i) display the strongest subject enjoyment,

This hypothesis is retained for both boys and girls (Section 7. 2.2).

ii) find the subject easiest,

This hypothesis is retained for both boys and girls (Table 5.5.4)

'Easiness' in this research has been defined as one pole of a 'slog' factor. 'Slog' measures the effort in studying a hard subject overloaded in content.

iii) are introverted,

This hypothesis is retained for both boys and girls (Section 7.3.4).

iv) show no specific anxiety characteristics,

On the evidence of Section 7.3.4 , this hypothesis is retained for girls but rejected for boys. Boys with the best O-level grades tend to be calm and stable rather than anxious.

v) have the strongest motivation,

On the evidence of Section 7.3.4, this hypothesis is retained for both boys and girls.

vi) have the best study habits,

On the evidence of Section 7.3.4 , this hypothesis is retained for boys but rejected for girls

vii) are taught in a learning environment where pupils preference is matched by reality,

This hypothesis is rejected for the boys but retained for the girls (Section 7.4.3).

viii) are taught in a learning environment where varied experiences, including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element,

This hypothesis is rejected for boys but retained for girls (Section 7.4.3). Attainment for boys, in general, shows little association with classroom environment variables.

Hypothesis 3.2(g)

Fifth-form physics pupils show the strongest enjoyment when taught in a learning environment

i) where pupil preference is matched by reality,

On the evidence of Section 7.4.2 , this hypothesis is retained for boys and for girls, taking the O-level examination. It is rejected for girls sitting for the C.S.E examination.

ii) where varied experiences, including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element,

From table 7.4.6 , this hypothesis is retained for boys and for girls taking the O-level examination. It is rejected for girls sitting for the C.S.E. examination.

Hypothesis 3.2(h)

Fifth-form physics pupils, when given a free choice of A-level subjects, choose to study those which they most enjoy.

This hypothesis is retained for both boys and girls (Section 7.6.5).

Hypothesis 3.2(i)

Fifth-form physics pupils, when faced with practical and career limitations on the choice of A-level subjects, choose a pattern that differs from 3.2(h).

The significant differences between free and bound choices of A-level subjects indicated in tables 7.6.5 and 7.6.6 cause this hypothesis to be retained for both boys and girls. In practice, boys move towards physics, mathematics and chemistry. They move away from biology, art and the humanities. Girls move towards physics and away from biology and French.

Hypothesis 3.2(j)

Fifth-form physics pupils, if intending to study A-level physics,

(i) are introverted,

From the evidence of Section 7.10.3 , this hypothesis is retained for boys and girls (no differential sex effect investigated).

ii) have high motivation,

From the evidence of Section 7.10.3 , this hypothesis is retained for boys and girls (no differential sex effect investigated). In addition, physics choosers have the higher subject motivation as well as the higher general motivation.

iii) dislike arts subjects

This hypothesis is retained for both boys and girls on the evidence of table 7.5.8 and Appendix 7.5.1. ('Arts' subjects are defined, here, as English literature, French and history).

(iv) choose physics because of career reasons

This hypothesis is retained for both boys and girls on the evidence of Sections 7.7.3 and 7.7.4.

v) have high Lie scores as measured by the Eysenck Personality Inventory,

This hypothesis is rejected on the evidence of Section 7.10.3 (no differential sex effect investigated). The Lie scale is assumed to be measuring a degree of social conformity (Section 7.3 and 7.12).

vi) display higher achievement as measured by the G.C.E. O-level /C.S.E. grade than those rejecting A-level physics

This hypothesis is retained on the evidence of Section 7.10.3 (no differential sex effect investigated).

Hypothesis 3.2(k)

Fifth-form physics pupils, if intending to reject physics in favour of other A-level subjects,

i) do so because the O-level course was difficult,

This hypothesis is retained for both boys and girls on the evidence of Sections 7.7.3 and 7.7.4. This rejection reason is likely to be the most important single reason for girls.

ii) do so because the O-level course was uninteresting

This hypothesis is retained for both boys and girls on the evidence of Sections 7.7.3 and 7.7.4. Lack of interest as a rejection reason is comparable with subject difficulty for boys but is of lesser importance for girls.

iii) display poorer attitudes towards O-level physics than do those choosing the subject

On the evidence of the identification and satisfaction variables in table 7.10.5 , this hypothesis is retained (no differential sex effect investigated).

Hypothesis 3.2(1)

Fifth-form physics pupils, whether boys or girls, show similar attitudinal responses and display similar choice/rejection patterns

Differential sex effects have been explored with the preceding hypotheses in most instances. The only exception has been in some comparisons of A-level physics choosers and rejectors, where the similarity between boy and girl choosers tends to be small enough (Section 7.5.6) for them to be considered, arguably, as one group before a more detailed cluster analysis.

As an overall hypothesis, 3.2(l) has to be rejected. Attitudinal differences between the sexes do occur in fifth-form classes, even though the girls have been 'selected' at some earlier stage to study physics. However, as the earlier hypothesis tests have shown, there is still considerable attitudinal agreement between boys and girls.

Hypothesis 3.2(m)

Fifth-form physics pupils comprise a number of recognisable stereotypes for whom achievement and enjoyment outcomes can be characteristically predicted

The detailed evidence in Section 7.11 permits this hypothesis to be retained. Cluster sizes are moderate and permit tests of significance between clusters but tests within clusters are limited. The composition of the clusters precludes the application of many of the hypotheses, for instance, hypothesis 3.2(d) refers to stable introverts, yet several of the clusters have been established by excluding such pupils.

The hypotheses that have been formulated and tested express a clear but broad picture of the outcomes in fifth-form physics classrooms. The typological analysis has been applied within this broad scheme to study the grain-like structure beneath an apparently smooth attitudinal 'surface'. Now, each identified cluster needs to be inspected and, possibly , characteristic hypotheses formulated. Alternatively, the more general hypotheses of this Section can be tested for each cluster- type in turn. The regression and factor analyses of Section 7.11 , have in effect performed tests on the two 'outcome' hypotheses of 3.2(b) and 3.2(g). The major results are

The enjoyment/attainment hypothesis 3.2(fi) is retained only for

a) the well adjusted, poor achievers, and

b) the sixth-form physics rejecting, neurotic extraverts (table 7.11.22).

The motivation/attainment hypothesis 3.2(fii) is retained for four groups only,

a) the anxious physicists (table 7.11.7),

b) the natural physicsts (table 7.11.9),

c) highly mis-matched, moderate achievers (table 7.11.11),

d) good-time, poor achieving extraverts (table 7.11.14).

The learning environment preference match/attainment hypothesis 3.2(f.vii) is rejected for all groups as is the varied teaching/attainment hypothesis 3.2(f.viii).

The learning environment preference match/enjoyment hypothesis 3.2(g.i) is retained for the group of natural physicists only (table 7.11.9)

The varied teaching/enjoyment hypothesis 3.2(g.ii) is rejected for all groups.

The failure to retain the learning environment/outcome hypothesis for the pupil-clusters must be viewed in the perspective of the whole classroom,where the learning environment variables provide the necessary structure to maximise success for five of the seven pupil stereotypes (Section 7.11.17).

Two of the three teacher hypotheses have been tested in Chapter 6, Section 6.4. The third:

Hypothesis 3.4(c)

Physics teachers' responses to a form of the Effective Science Teaching Questionnaire permit mean class achievement and enjoyment outcomes to be related to teachers' preferred behaviours

is retained on the evidence of tables 7.9.2 and 7.9.7. Teachers who strongly appreciate the need for a learning-theory base in teaching are likely to be found with high achievement classes. Other preferred teaching behaviours show significant association with enjoyment as well as attainment when a typology of classes is investigated. It is worth noting that when class performance is analysed, an experience of the varied, teaching for understanding method correlates significantly with mean pupil attainment (table 7.9.2).

CHAPTER 8

<u>TEST RESULTS IN THE LOWER SIXTH-FORM</u>

8.1 INTRODUCTION

8.1.1 DATA COLLECTED WITH THE UNIT 4 QUESTIONNAIRE

The construction of the lower sixth-form questionnaire (Unit 4) was described in Section 4.5. Pre-test course attitudes in physics were measured and details have been given in Section 5.9. Changes in attitudes over the two year A-level course are described in Section 9.2.

Two further scales gave retrospective measures of fifth-form examination preparation (Section 5.8 and 7.8), and reasons for choosing and rejecting A-level physics. The purpose of the latter was for comparison with the responses given several months before in the fifth-form, in the event that the students starting A-level physics in the sixth-form were not exactly the same ones who had expressed an intention to do so earlier. Changes in the patterns of choice and rejection reasons as the pupils move into the sixth-form are explored in Section 8.3.

It is reasonable to expect some changes in the composition of the A-level physics choosing and rejecting groups from the fifth-form. Performance in the G.C.E. O-level examinations will undoubtedly affect the proposed intentions of some of the pupils. Whereas some will do better than expected and possibly choose A-level physics, having rejected it when asked in the fifth-form, others will find themselves in exactly the opposite position.

It is possible that the significant differences between the potential sixth-form physics choosing and rejecting groups, as earlier revealed in table 7.10.5, are not maintained when these groups eventually re-form at the commencement of A-level studies. In this Chapter, and particularly in Section 8.2, the attitudinal differences between the sixth-formers choosing and rejecting physics will be reviewed and certain student sub-populations investigated.

8.1.2 A REDUCED LOWER SIXTH-FORM POPULATION

Table 8.1.1 compares the fifth- and sixth-form sample sizes.

TABLE 8.1.1 FIFTH-FORM AND SIXTH-FORM SAMPLES COMPARED

Population sub-group		Fifth-form (potential sixth-form)	Lower sixth-form
Choosing	Boys	187	125
A-level	Girls	43	36
physics	All	230 (4.56)	161 (4.84)
Rejecting	Boys	122	48
A-level	Girls	90	40
physics	All	212 (3.53)	88 (4.50)

Mean attainment scores are in brackets

As the criterion for selecting the lower sixth-form sample was success in the O-level physics examination, failure to reach a pass-grade (C) reduced the size of the rejectors' group considerably (the mean grade of those eliminated in this way was D/E).

The choosers' group also suffers a reduction in size, mainly because of the boys' contribution. Poorer G.C.E. grades than expected are a factor here, too. (A score of 4.00 is equivalent to a grade C pass).

In addition, some pupils transferred to schools and colleges outside the survey area, while others started the A-level course only to transfer or leave after a few weeks.

8.1.3. FOUR STUDENT SUB-GROUPS

The transition from fifth-form to sixth-form permits four possible student sub-groups;

1. '<u>consistent choosers</u>', who chose A-level physics when in the fifth-form and subsequently start the course;
2. '<u>drop outs</u>', who choose A-level physics when in the fifth-form but do not start the A-level course. This group may be further classified into 'qualified' drop-outs, who have O-level physics passes, and 'unqualified' drop-outs, who do not;
3. '<u>converts</u>', who do not choose A-level physics when in the fifth-form but subsequently change their minds and start the A-level course, and
4. '<u>consistent rejectors</u>', who do not choose A-level physics when in the fifth-form and keep to this decision in the sixth-form.

Differences between these student sub-groups are explored in Section 8.2.

8.2. THE TRANSITION GROUPS - ATTITUDES AND ATTAINMENT COMPARED

8.2.1. DIFFERENCES BETWEEN THE BROAD PHYSICS CHOOSING AND REJECTING GROUPS IN THE SIXTH-FORM

This first part of the investigation combines the consistent choosers and converts to form a broad physics choosing group and combines the drop-outs and consistent rejectors into a broad physics rejecting group. Table 8.2.1 compares the mean scores on the fifth-form variables for pupils who are either in first year A-level (lower sixth-form) physics classes, or having obtained an O-level pass in physics, are studying other subjects.

TABLE 8.2.1. THE CHARACTERISTICS OF PHYSICS CHOOSERS AND REJECTORS IN THE SIXTH-FORM

	Mean score (standard deviation)			
	Pupils choosing A-level physics (N = 161)		Pupils rejecting A-level physics in the sixth-form (N = 88)	
Variable				
PERFORM	4.84	(0.86)	4.50	(0.64)**
PHYSID	71.22	(10.96)	62.61	(10.18)**
STUDYHAB	5.40	(1.99)	5.83	(2.12)
MOT	11.35	(2.26)	10.85	(2.54)
EXTRAV	11.72	(4.37)	13.19	(4.28)**
NEUROT	10.80	(4.00)	10.69	(4.07)
LIE	2.93	(1.48)	2.80	(1.80)
LBE	21.76	(3.89)	20.92	(3.67)
ITS	3.29	(0.95)	2.99	(0.93)*
PHYSHAB	6.09	(2.09)	5.80	(2.32)
PHYSMOT	12.51	(2.01)	11.16	(2.85)**
VARUND (P)	26.16	(2.17)	25.89	(2.61)
VARUND (E)	22.81	(3.72)	22.26	(3.51)
VARUND (M)	3.35	(3.96)	3.63	(3.55)
MATCH	10.27	(3.46)	9.90	(3.43)
SAT	10.66	(1.45)	9.05	(1.90)**
SLOG	3.63	(1.39)	4.70	(1.21)**
IMPORT	3.48	(0.64)	3.02	(0.66)**
EXAM	160 G.C.E.	: 1 C.S.E.	89 G.C.E.	: 1 C.S.E.
SEX	125 boys	: 36 girls	48 boys	: 40 girls**
No. of O-levels	6.70	(1.92)	7.44	(1.52)**
Examination preparation 'match	3.95	(1.60)	3.51	(1.47)*

** p < 1%: * p < 5% (t-test except SEX, χ^2)

Some of the more extreme differences shown when the analysis is conducted using the fifth-form pupils' intentions, rather than the reality of the sixth-form transition (table 7.10.5), have now been modified. Table 8.2 shows that no longer do the physics rejectors come from such sharply mis-matched classes of relatively low 'varied, teaching-for-understanding' rating . Pupils who found themselves in these classes, apparently, did not do well in the O-level examination or left school. No longer are the general academic motivation and study-habits variables significant discriminators: <u>pupils with the poorer characteristics have eliminated themselves</u> here, as well.

Attitudes and attainment in physics are still superior for the physics choosers, but not to such a strong degree as before. The physics rejectors find the subject just as difficult as in the fifth-form analysis and have similar extraversion characteristics. <u>The more anxious physics rejectors have apparently been eliminated</u> at the O-level examination hurdle: there is no difference in the anxiety scores for the two groups in table 8.2.1.

One of the two additional variables in table 8.2.1 , the number of O-level passes, indicates that the physics rejectors might be of better all-round ability than the 'choosers', although in physics the latter get the better grades. The second additional variable is a measure of how closely the O-level physics revision and examination preparation matched the pupils needs (Sections 5.8 and

7.8). Physics choosers are seen to receive the better 'match'.

8.2.2. PHYSICS CHOOSERS WHO 'DROP OUT'

By comparing mean scores on the fifth-form variables for those pupils who carry out their expressed intention to take A-level physics (the 'consistent choosers') with those who, for various reasons, 'drop out' from the physics population after having chosen the subject at the end of the fifth-form course, it is possible to discover other characteristics of the 'drop-out' group.

The 'drop-out' effect is seen from table 8.2.2 to be a cognitive rather than an affective phenomenon. Perceived subject difficulty and a tendency towards an extraverted personality disposition are both likely to depress examination performance into the fail category. The mean attainment score of 3.76 indicates a G.C.E. grade of C/D.

A confirmation that poor attainment is the major factor at work in the drop-out phenomenon is obtained from the patterns of reasons given by this pupil group when they were asked in the fifth-form why they intended to study A-level physics. The groups of reasons attracting the strongest support were (i) career needs (ii) intrinsic subject interest and (iii) an attractive subject 'image' (table 8.2.3). The four cognitive groups of reasons, expressing a choice because of subject mastery, are less often given.

TABLE 8.2.2. PHYSICS 'DROP-OUTS' AND 'CONSISTENT CHOOSERS' COMPARED

	Mean score (standard deviation)			
Variable	Pupils choosing A-level physics in the fifth-form but subsequently 'dropping-out' (N = 79)		Pupils choosing A-level physics in the fifth-form and subsequently starting the course (N = 151)	
PERFORM	3.76	(1.41)	4.83	(0.89)**
PHYSID	70.23	(8.59)	71.93	(10.62)
STUDYHAB	5.35	(2.25)	5.36	(1.97)
MOT	11.14	(2.09)	11.48	(2.24)
EXTRAV	13.11	(3.54)	11.64	(4.42)**
NEUROT	10.39	(3.86)	10.71	(3.86)
LIE	2.94	(1.91)	2.98	(1.45)
LBE	21.71	(3.28)	21.58	(3.35)
ITS	3.28	(0.85)	3.35	(0.90)
PHYSHAB	6.04	(2.18)	6.03	(2.12)
PHYSMOT	12.25	(2.10)	12.68	(1.83)
VARUND (P)	26.48	(2.10)	26.23	(2.12)
VARUND (E)	22.76	(3.48)	22.97	(3.71)
VARUND (M)	3.72	(3.56)	3.26	(3.90)
MATCH	10.32	(3.76)	10.42	(3.43)
SAT	10.32	(1.72)	10.73	(1.41)
SLOG	4.23	(1.28)	3.60	(1.39)**
IMPORT	3.38	(0.67)	3.52	(0.63)
EXAM	72 G.C.E.	: 7 C.S.E.	150 G.C.E.	: 1 C.S.E.**
SEX	67 boys	: 12 girls	120 boys	: 31 girls

**p < 1%: * p < 5% (t-test, except EXAM, χ^2)

TABLE 8.2.3. REASONS FOR STUDYING PHYSICS - PUPILS WHO SUBSEQUENTLY 'DROPPED-OUT'

Choice area	Number of reasons within area	Percentage of students (N=79) giving at least one reason in the area
1. Easy to pass physics exams	3	13
2. Confidence to tackle a difficult A-level course	2	48
3. Good O-level performance in physics	2	63
4. Attractive subject educationally	3	75
5. Intrinsic subject interest	2	80
6. Easy and mathematical	2	51
7. Career needs	1	87

8.2.3. THE PROBLEM OF THE 'QUALIFIED' DROP-OUTS

Of the 79 pupils 'dropping-out' from the A-level physics population, some 17 actually started other sixth-form studies despite gaining an O-level physics pass. For these pupils, apparently it is not subject difficulty which causes a change in plan. Comparing the characteristics of these pupils (N = 17) with the consistent physics choosers (N = 151) shows that only one variable gives significantly different mean scores: <u>the physics choosers rate the subject image of physics more highly</u> (mean scores are in the ratio of 10.73 to 9.88 and the standard deviation ratio is 1.41 to 1.87).

Taking into account the choice and rejection reasons, certain hypotheses can be generated. Tables 8.2.4 and 8.2.5 show that while at the fifth-form level career requirements supply a unanimous reason for going on to A-level physics, when it comes to actually making the choice in the sixth- form, career requirements for half the pupils have apparently changed and this is now a reason for <u>not</u> taking up the subject.

TABLE 8.2.4. THE REASONS FOR CHOOSING PHYSICS COMPARED IN THE FIFTH-FORM

Choice area	Number of reasons within area	Percentage of students giving at least 1 reason in the indicated area: 'drop-outs' (N = 17)	consistent choosers (N = 151)
1. Easy to pass physics exams	3	12	20
2. Confidence to tackle a difficult A-level course	2	47	51
3. Good O-level performance in physics	2	65	72
4. Attractive subject educationally	3	82	64
5. Intrinsic subject interest	2	77	75
6. Easy and mathematical subject	2	41	64
7. Career needs	1	100	89

There are no significant differences (χ^2-test) in the patterns of choice reasons between the physics choosers and the 17 'drop-outs'.

TABLE 8.2.5. THE REASONS FOR REJECTING PHYSICS COMPARED IN THE SIXTH-FORM

Rejection area	Number of reasons within area	Percentage of students giving at least one reason in the area: 'drop-outs' (N = 17)	consistent rejectors (N = 71)
1. All-round unattractive subject	7	76	86
2. Low grade in a difficult subject	3	65	66
3. Too mathematical	2	29	28
4. Difficult A-level course	2	29	28
5. Career and timetable requirements	2	53	51

Again there are no significant differences (χ^2-test) between the'drop-outs' and the major group, in this case the consistent rejectors.

In the sixth-form, the 'drop-outs' are as likely to give rejection reasons in the 'all-round boring subject' category as are the consistent rejectors. This is a reflection of the relatively poor subject image held by the 'drop-outs' in the fifth-form. What remains a puzzle is why the pupils rated 'attractiveness' reasons so highly when choosing the subject in the first place. Possibly, having chosen the subject primarily for career reasons, the pupils sought to justify this choice by giving the subject a superficial 'liking' rating. The real sixth-form world required a firm choice: superficiality is swept away - physics was not really liked, and another career area might be beckoning, so physics is rejected.

There is no evidence that the 'drop-outs' gain poorer O-level physics grades than expected. Indeed, to the contrary, as table 8.2.6 shows the 'drop-outs' are just as likely to achieve their estimated grade as are the consistent choosers.

TABLE 8.2.6. PHYSICS GRADES COMPARED WITH PUPILS' ESTIMATES

Population sub-group	Correlation between expected physics grade and actual grade (A=6, B=5, etc)
Drop-outs with physics passes (N = 17)	0.62**
Consistent rejectors (N = 71)	0.28*
Consistent choosers (N = 149) +	0.51**
Converts (N = 10)	0.15

**p < 1%; * p < 5%

+Two pupils were unable to estimate their O-level grades before the exam

The insignificant correlation between estimate and achievement for the 'converts' in table 8.2.6 reflects the situation where seven of the pupils do better than expected, gaining passes at Grade B rather than at Grade C.

Table 8.2.7 gives a cross-tabulation of intended career areas for the 17 drop-outs; firstly, as expressed in the fifth-form choices. The latter show a clear swing against science at A-level, with only four students specialising in this area, and even those four will not be studying physics. Of the ten fifth-formers choosing science, eight move out of this intended career area in the sixth-form. This is strong support for the hypothesis that

TABLE 8.2.7. CHANGES IN CAREER-AREAS : DROP-OUTS

	Career area							
		Higher education						
	Manual, realistic	applied science	science/ medicine	other	Social	Conven- tional	Enter- prising	None given
Fifth-form	2	4	6	0	1	1	2	1
Sixth-form	3	2	2	2	2	5	0	1

the qualified 'drop-outs' are relatively able pupils who either change their career aspirations upon entering the sixth-form or discover that they no longer have to maintain their shallow allegiance to physics.

8,2.4. THE CHARACTERISTICS OF THE PHYSICS 'CONVERTS'

Table 8.2.6 has shown that 'converts' to A-level physics are less likely to be able to predict their O-level physics performance than are the other pupil groups. Doing better than expected in an anticipated difficult subject (table 8.2.8 shows that six of the ten 'converts' gave perceived A-level difficulty as a rejection reason in the fifth-form) persuades the 'converts' that physics might not be so difficult, after all.

TABLE 8.2.8. REJECTION REASONS GIVEN BY 'CONVERTS' IN THE FIFTH-FORM

Rejection area	Number of reasons within area	Percentage of students (N=10) giving at least one reason in the area
1. All-round unattractive subject	7	50*
2. Low grade in difficult subject	3	50
3. Too mathematical	2	20
4. Difficult A-level course	2	60
5. Career and timetable requirements	2	20

* Highest 'score' was just three of the seven reasons

TABLE 8.2.9. CHOICE REASONS GIVEN BY 'CONVERTS' IN THE SIXTH-FORM

Choice area	Number of reasons with-in the area	Percentage of students (N=10) giving at least one reason in the area
1. Easy to pass physics exams	3	10
2. Confidence to tackle a difficult A-level course	2	40
3. Good O-level performance in physics	2	70
4. Attractive subject educationally	3	60
5. Intrinsic subject interest	2	60
6. Easy and mathematical subject	2	30
7. Career needs	1	60

TABLE 8.2.10. CHANGES IN CAREER-AREAS : CONVERTS

	Career Area					
		Higher education:				
	Manual, realistic	applied science	science/ medicine	Social	Conven-tional	None given
Fifth-form	2	2	2	0	0	4
Sixth-form	0	4	3	0	1	2

This hypothesis is supported by the evidence from table 8.2.9 , which shows that most of the pupils give a good O-level physics performance as a choice reason when they are asked in the lower sixth-form why they are studying A-level physics. Unexpected success in physics opens up new career possibilities (table 8.2.10 shows a shift towards science) which becomes rationalised as 'A-level physics is needed for my career', as a choice reason. It is noticeable that the career choice reason is popular in the sixth-form (table 8.2.9). This might also indicate that some of the 'converts' were not fully aware at the fifth-form stage of the curricular implications of their career choices. Although not intending to take A-level physics, despite a moderate pass-grade, say, the reality of the transition from fifth-to sixth-form brings home to the pupils the necessity of taking this subject at A-level.

Table 8.2.11 compares converts with consistent choosers and reports significant differences between mean scores. There is no significant difference in physics attainment but the converts are more likely to be girls (i) who experience less of the varied, teaching-for-understanding approach in a 'mis-match' classroom where the teacher's style tends to be unattractive; (ii) whose attitudes towards the subject are less favourable, and (iii) whose motivation to get a high grade in the O-level physics examination is less strong than the 'consistent' choosers.

TABLE 8.2.11. PHYSICS'CONVERTS' AND 'CONSISTENT CHOOSERS' COMPARED

Variable	Mean score (standard deviation)					
	Consistent physics choosers (N = 151)			Physics 'converts' (N = 10)		
PHYSID	71.93		(10.63)	60.60		(10.88)**
ITS	3.35		(0.90)	2.30		(1.06)**
VARUND (E)	22.97		(3.71)	20.30		(3.09)*
MATCH	10.42		(3.43)	8.10		(3.21)*
SAT	10.73		(1.41)	9.70		(1.77)*
IMPORT	3.52		(0.63)	3.00		(0.67)**
SEX	120 boys	:	31 girls	5 boys	:	5 girls*

** $p < 1\%$: * $p < 5\%$ (t-têst except SEX, χ^2)

8.2.5. CONCLUDING REMARKS

Real attitudinal and attainment differences still exist between A-level physics choosers and rejectors in the sixth-form although these are not as severe as appeared at the fifth-form level, where the extensive population of rejectors included a proportion of low-achieving pupils who were never serious candidates for sixth-form physics study. As might be expected subject difficulty, motivation, attitudes and O-level attainment are effective discriminators between the choosers and rejectors. A less obvious discriminator is O-level teaching style: an 'interesting' classroom manner is associated with the choice of sixth-form physics. This suggests that 'liking the teacher' and a possible personality match between pupils and teacher have a part to play in choosing the subject. Ormerod (1975) has found that 'liking the teacher' is an important correlate with subject choice at the adolescent stage. There is some evidence here that it plays a part in the transition to A-level, too.

Fifth-form physics choosers, who find the subject most difficult and who are extraverted, are the pupils most likely to drop-out before the sixth-form, for the most part, because of poor O-level achievement. A smaller group of relatively able 'qualified drop-outs', have the opportunity to study physics in the sixth-form but, re-evaluating the need for this subject in their career plans, find it unnecessary.

A small group of 'convert' pupils, who do better than expected in the physics examination, change their minds and continue with physics in the sixth-form despite holding inferior attitudes and experiencing an apparently unfavourable classroom environment. Thus, for some pupils academic success is able to over-ride otherwise inhibiting affective and organisational climates.

The existence of 'converts' and 'qualified drop-outs' is inevitable rather than a consequence of certain desirable, or undesirable, classroom characteristics and teacher behaviour. Some pupils will always do better in examinations than expected and will form a 'convert' group. Others will change their career plans, as areas of interest shift; and join the 'qualified drop-outs'.

8.3. CHANGES IN A-LEVEL PHYSICS CHOICE AND REJECTION REASONS ON ENTERING THE SIXTH-FORM

8.3.1. COLLECTING THE DATA

When asked why A-level physics might be chosen or rejected, fifth-form pupils gave its suitability as a career qualification and perceived O-level course difficulty, respectively, as major reasons (Section 7.7.6). The check-list used to ascertain the pupils' reasons has been described in Section 5.7. After re-administering this check-list in the lower sixth-form, each student had two scores for each item. The statistical significance of the difference in response on the two occasions was tested by the non-parametric McNemar Test (Siegel, 1956).

8.3.2. CHANGES IN CHOICE REASONS

The number of physics choosers declined by 86 from those expressing an intention to take A-level physics when asked in the fifth-form. There was a possibility that this reduction in sample size might distort the validity of the overall pattern of choice reasons given by the full fifth-form sample of Section 7.7.1. In other words, the fifth-form pattern of responses summarised by figure 7.7.1 might <u>not</u> be applicable to the sample of choosers who finally start the A-level course. To check this, the fifth-form analysis was repeated for the lower sixth-formers only with the results shown in figure 8.3.1. It is clear that the two figures are very similar and that the loss of 86 pupils has had no noticeable distorting effect.

Table 8.3.1 shows the differences in responses to the check-list items between the fifth- and sixth-forms.

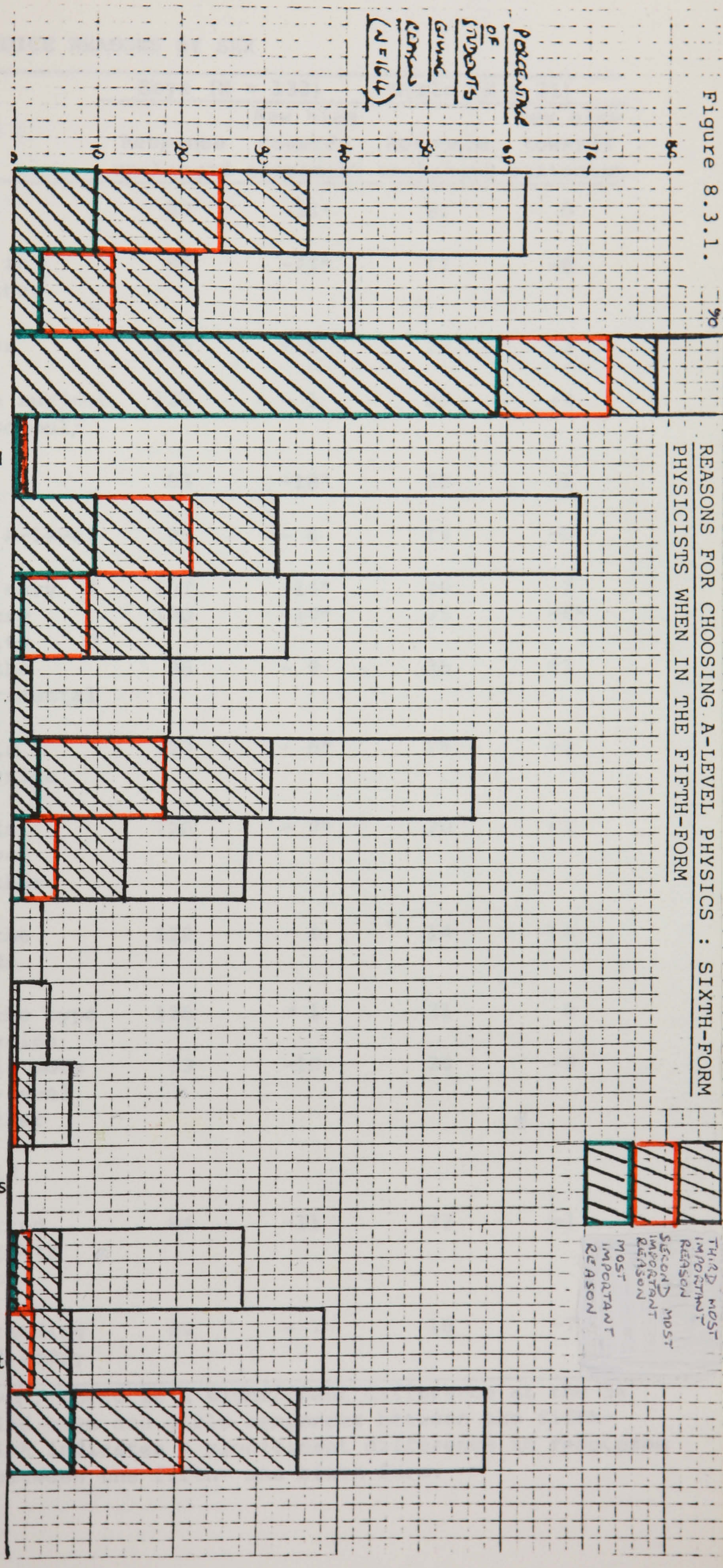
Figure 8.3.2 displays the sixth-form responses and permits a ready comparison with those given in the fifth-form (figure 8.3.1).

There is a clear lessening of support for the high physics grade reasons (statements 1 and 2). Overall, the career requirements reason continues to dominate and it is now the most important reason for more students. The relative support given to all the other reasons remains broadly the same in the sixth-form, with the tendency for a slight reduction all round.

8.3.3. CHANGES IN REJECTION REASONS

In the sixth-form, just 72 students with O-level physics passes remained from the 234 in the 'rejectors' category who completed the fifth-form check-list. It

Figure 8.3.1. REASONS FOR CHOOSING A-LEVEL PHYSICS : SIXTH-FORM PHYSICISTS WHEN IN THE FIFTH-FORM



1. You have a high O-level physics grade
2. You have a better grade in physics
3. University and/or career requirements
4. Not a main subject: decided by timetable
5. The O-level course was interesting
6. You have heard the A-level course is interesting
7. The O-level course was easy
8. Allows mathematical ability to be expressed
9. Attracted by experimental work
10. Not so much hard work in A-level physics
11. Easier to pass in A-level physics
12. Attracted by A-level teaching methods in physics
13. Attracted by A-level physics examinations
14. More difficult to pass in A-level physics but confident
15. More hard work but confident
16. To improve your understanding of science in the world today.

TABLE 8.3.1 CHANGES IN CHOICE REASONS BY SEX

Statement	Boys (N = 133)		Girls (N = 31)	
	Response unchanged	New bias towards statement	Response unchanged	New bias towards statement
1 You had a high O-level physics grade †	82	-43*	21	0
2 You had a better grade in physics than in most other subjects †	84	-33*	17	-8
3 University and/or career requirements	116	+ 5	28	-3
4 It was not to be a main subject but it was decided by school/ college timetable	128	- 1	29	+2
5 The O-level course was interesting †	85	-18*	20	-1
6 You had heard that the A-level course is interesting	99	- 6	19	-6
7 The O-level course was easy †	107	-14*	29	2
8 Physics allows you to use your mathematical ability †	100	-19*	25	-6*
9 You were attracted by the amount of student experimental work in physics	96	- 9	26	+3
10 Not so much hard work is expected in A-level physics as in other subjects	127	- 6*	29	+2
11 You had heard that it is easier to pass in A-level physics than in most other subjects	126	- 7*	30	+1
12 You were attracted by the A-level teaching methods in physics	122	- 1	24	+1
13 You were attracted by the type of exams in A-level physics	126	+ 1	31	0
14 You had heard that it is more difficult to pass in A-level physics than in most other subjects, but you were confident that you could manage	93	-10	20	-3
15 More hard work is expected than in some other subjects but you thought that you could manage	84	-11	22	-1
16 To improve your understanding of science in the world today	82	- 7	18	-7

For a statement denoted by †, there is a significant difference at the 5% level at least in the pooled boys and girls responses between the fifth- and sixth-form. An asterisk indicates a significant difference in responses at the 5% level at least between the fifth- and sixth-form.

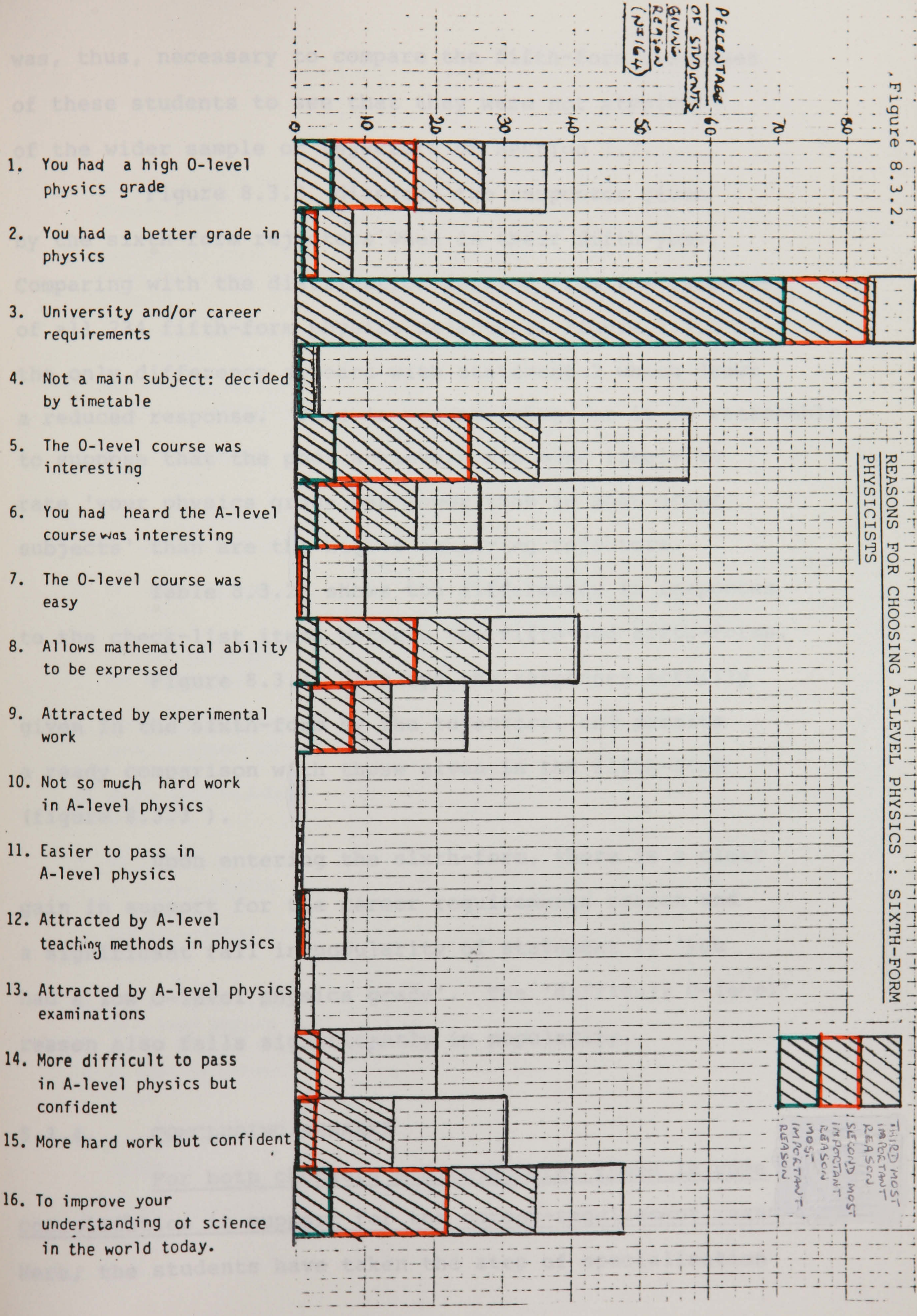


Figure 8.3.2.

REASONS FOR CHOOSING A-LEVEL PHYSICS : SIXTH-FORM PHYSICISTS was, thus, necessary to compare the fifth-form responses of these students to see that they were not atypical of the wider sample of rejectors of Section 7.7.

Figure 8.3.3 displays the responses given by the sixth-form rejectors when in their fifth-year. Comparing with the distribution derived from the responses of all 234 fifth-form physics rejectors, figure 7.7.2 , the only difference appears with statement 2 which draws a reduced response. This is unsurprising, as it is reasonable to suppose that the poor achievers are more likely to rate 'your physics grade was lower than in most other subjects' than are the higher achieving rejectors.

Table 8.3.2 shows the differences in responses to the check-list items between the fifth-and sixth-forms.

Figure 8.3.4 displays the responses actually given in the sixth-form by the rejectors, and permits a ready comparison with those given in the fifth-form (figure 8.3.3).

Upon entering the sixth-form, there is a clear gain in support for the career requirements reason and a significant fall in popularity of statement 1: 'you had a low O-level physics grade'. The 'difficult O-level' reason also falls significantly in popularity.

8.3.4. CONCLUDING REMARKS

For both choosers and rejectors, there is some consolidation in support for the career-requirement reason. Here, the students have taken the step of specialisation

1. You have a low O-level physics grade
2. Your physics grade is lower than grades in other subjects
3. University and/or career requirements
4. Not main subject and timetable difficulties
5. O-level course not interesting
6. Heard that A-level course is not interesting
7. O-level course was difficult
8. O-level course was too mathematical
9. Not enough experimental work in O-level course
10. Harder work in A-level physics
11. More difficult to pass in A-level physics
12. Not attracted by A-level teaching
13. Not attracted by type of A-level physics exam
14. No room for personal views
15. Too narrow and specialist
16. A-level course is too mathematical

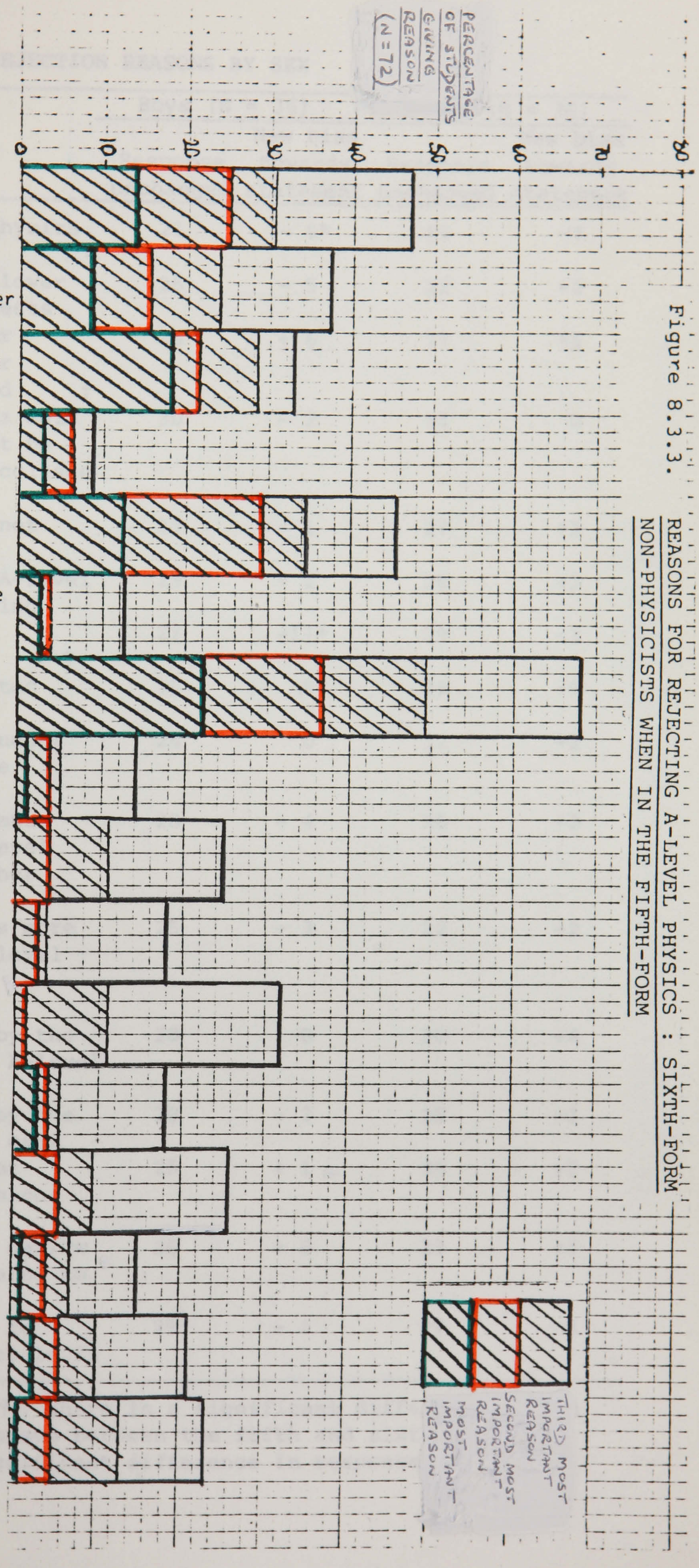


Figure 8.3.3. REASONS FOR REJECTING A-LEVEL PHYSICS : SIXTH-FORM NON-PHYSICISTS WHEN IN THE FIFTH-FORM

TABLE 8.3.2. CHANGES IN REJECTION REASONS BY SEX

Statement	Boys (N = 36)		Girls (N = 36)	
	Response unchanged	New bias towards statement	Response unchanged	New bias towards statement
1 You had a low O-level physics grade †	21	- 9*	19	-7
2 Your physics grade was lower than in most other subjects	25	- 5	22	-2
3 University and/or career requirements meant other subjects must be studied †	24	+ 6	27	+5
4 It would not have been a main subject and it could not be fitted into the school/college timetable	30	- 2	34	0
5 The O-level course was not interesting	25	- 1	27	+3
6 You had heard that the A-level course was not interesting	29	+ 1	26	+2
7 The O-level course was difficult †	23	-11*	29	-3
8 The O-level course was too mathematical	30	0	29	+5
9 There was not enough student experimental work in the O-level course	24	0	32	-2
10 You had heard that you must work much harder in A-level physics than in most other subjects	28	- 4	26	-2
11 You had heard that it is more difficult to pass at A-level in physics than in most other subjects	25	- 3	22	-2
12 You were not attracted by the teaching methods of the A-level physics course	28	0	30	+4
13 You were not attracted by the type of A-level physics exam	29	- 3	25	-1
14 A-level physics would not allow your personal opinions to be expressed	25	+ 1	34	+2
15 A-level physics was too narrow and specialist to be useful to you	26	+ 6	23	+3
16 The A-level course seems to have too much mathematics in it	29	- 1	29	+5

For a statement denoted by † , there is a significant difference in the pooled boys and girls responses between the fifth and sixth-forms. An asterisk indicates a significant difference in responses at the 5% level at least.

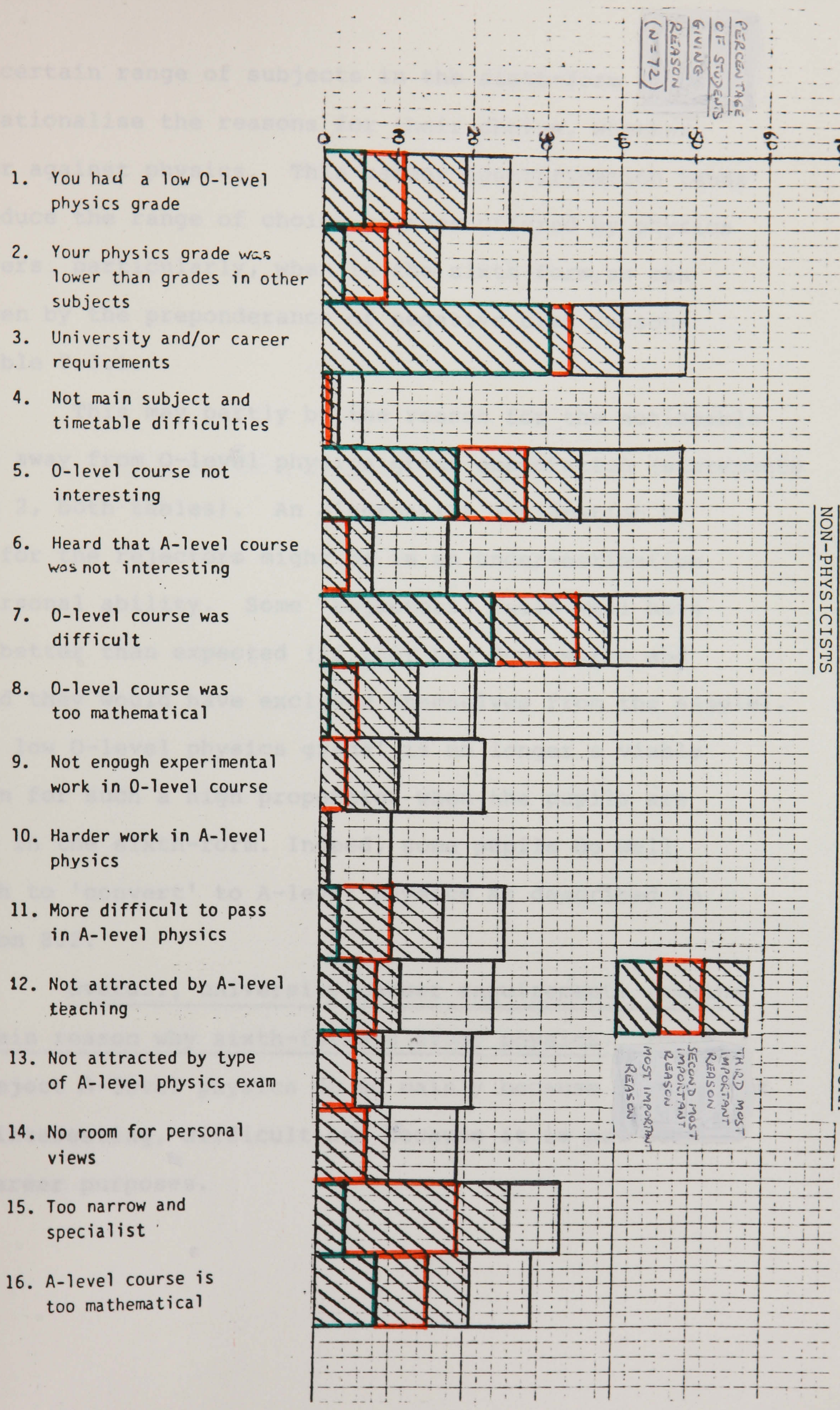


Figure 8.3.4. REASONS FOR REJECTING A-LEVEL PHYSICS : SIXTH-FORM NON-PHYSICISTS

in a certain range of subjects in the sixth-form and now rationalise the reasons for their choice, whether for or against physics. This career identification tends to reduce the range of choice reasons offered by physics choosers particularly, when in the sixth-form, as can be seen by the preponderance of negative bias reasons in table 8.3.1.

This may partly be the reason for the noticeable shift away from O-level physics grade expectation (statements 1 and 2, both tables). An alternative explanation of this for the rejectors might be in an under-estimation of personal ability. Some 'rejectors' could well have done better than expected (if they had done worse and failed they would have excluded themselves from the sample), so 'a low O-level physics grade' is no longer a viable reason for such a high proportion when the pupils are asked in the sixth-form. Indeed, some pupils do well enough to 'convert' to A-level physics as described in Section 8.2.

<u>Overall, university/career requirements remains the main reason why sixth-formers study physics.</u> Those who reject A-level physics do so mainly because the subject is uninteresting, difficult and because it is not needed for career purposes.

CHAPTER 9

TEST RESULTS IN THE UPPER SIXTH-FORM

9.1. INTRODUCTION

The results obtained with the sixth-form scales described in Chapter 5 are analysed in some detail in succeeding Sections of the present Chapter. There is an inevitable overlap with the item scores and analyses of Chapter 5 as the investigation is pursued in terms of sex differences, regressions on the major criterion outcomes (Sections 9.2 to 9.4) and a typology of sixth-form physics students (Section 9.5). Summary Section 9.6 is in the form of a test of the relevant research hypotheses from Chapter 3.

9.2. COURSE ATTITUDES AND ATTAINMENT IN THE SIXTH-FORM

9.2.1. ATTITUDE AND ATTAINMENT CHANGES DURING THE COURSE

Pre-and post-test scores for boys and girls have been given in Section 5.9. In terms of the composite enjoyment and easiness scales, the differences are summarised in table 9.2.1.

TABLE 9.2.1. PRE-TEST/POST-TEST DIFFERENCES ON THE COMPOSITE SCALES

Composite scale	Mean score			
	Boys (N = 108)		Girls (N = 35)	
	Pre-test	Post-test	Pre-test	Post-test
Enjoyment	25.15 (5.33)	22.48** (6.01)	23.63 (4.96)	23.49 (4.79)
Easiness	11.31 (3.15)	11.77 (4.01)	9.43 (2.62)	10.63* (2.67)

Standard deviations are shown in brackets
**$p < 1\%$ (deterioration, correlated t-test)
* $p < 5\%$ (improvement, correlated t-test)

Although the enjoyment of the boys has deteriorated significantly, this is clearly not the case for the girls, whose attitudes remain remarkably stable. The girls find the course easier as it nears its end than was the case at the beginning. At the pre-test stage, the girls find the courses significantly more difficult than the boys.

The relative changes in enjoyment and easiness for boys and girls are best compared by the method of residual change analysis (Section 2.9). Pre-test scores on the composite enjoyment and easiness scales were taken as predictor variables. The corresponding post-test scores were the dependent or criterion variables. From the multiple regression equation, residuals were calculated as explained in Section 2.9 and the values for the boys and girls compared (table 9.2.2). The cognitive changes in the sixth-form course were similarly investigated by performing the residual analysis on the G.C.E. A-level physics grades achieved by the students with the O-level physics grade as the predictor. (Grades were converted to a numerical scale, as usual, with A-level grade A ≡ 7, grade B ≡ 6, etc.)

TABLE 9.2.2. SEX DIFFERENCES IN RESIDUALS

Variable	Mean residual score	
	Boys (N = 92)	Girls (N = 32)
Enjoyment	-0.53 (4.87)	1.52 (4.42)*
Easiness	0.06 (3.44)	-0.18 (2.68)
Attainment	0.00 (1.56)	0.00 (1.37)

Standard deviations are shown in brackets
* $p < 5\%$ (t-test)

As later steps in the analysis of residuals required each student to have scored on the whole range of survey variables, the numbers of boys and girls reflect this criterion. Appendix 9.2.1 shows that this slight reduction in sample size has a negligible effect on attitude scores.

Table 9.2.2 shows that the enjoyment changes during the sixth-form course differ significantly across the sexes. Care must be taken when interpreting residuals: they are not absolute measures. The positive residual for the girls simply means that the girls do better than expected in maintaining their enjoyment: boys do worse and their enjoyment falls. The other two variables show no significant sex differences.

Changes on the 'minor' attitude scales (items 2, 6, 8, 10 and 13) during the sixth-form are few (table 9.2.3). The boys' ratings on the 'modern' scale drop and social implications are less often considered. The girls' attitudes remain stable.

TABLE 9.2.3. PRE-TEST/POST-TEST DIFFERENCES ON THE MINOR SCALES

Minor scale	Mean score			
	Boys (N=108)		Girls (N=35)	
	Pre-test	Post-test	Pre-test	Post-test
2. Present day theories are considered , only	-1.19 (1.22)	-1.15 (1.27)	-1.37 (1.03)	-1.26 (0.98)
6. High prestige	1.38 (1.15)	1.26 (1.30)	1.54 (1.25)	1.06 (1.26)
8 Social implications always considered	-0.31 (1.37)	-0.87** (1.48)	0.00 (1.28)	-0.26 (1.36)
10 Makes you think deeply about your personal views	-0.44 (1.57)	-0.63 (1.82)	-0.40 (1.68)	-0.54 (1.76)
13 Out-of-date	-0.94 (1.30)	-0.63* (1.29)	-1.31 (0.99)	-1.03 (1.07)

Standard deviations are shown in brackets
** $p < 1\%$; * $p < 5\%$ (correlated t-test)

9.2.2. THE CHARACTERISTICS OF STUDENTS WHO SHOW ENJOYMENT 'GAIN' OVER THE COURSE

Two groups were identified. Group A comprised students who showed a higher enjoyment score at the end of the course than at the beginning. Group B comprised those who showed a deterioration in attitude. Mean scores on a range of the survey variables were calculated for each group and tested for significance with the 't'-statistic.

TABLE 9.2.4. DIFFERENCES BETWEEN ENJOYMENT GROUPS

Variable	Mean score (standard deviation) Group A (N=40)	Group B (N=78)
Physics A-level grade (7 to 1)	3.95 (1.72)	3.60 (1.83)
Physics O-level grade (6 to 1)	5.03 (0.73)	4.90 (0.78)
A-level ability score	4.08 (1.42)	3.72 (1.61)
Fear-of-failure	10.78 (3.18)	10.68 (2.93)
Syllabus-boundness	12.80 (2.94)	12.92 (3.11)
Study methods	20.85 (5.34)	19.14 (4.94)
Intrinsic motivation	10.18 (3.74)	9.42 (2.97)
Extrinsic motivation	14.13 (2.36)	13.50 (2.69)
Academic motivation	13.43 (3.32)	12.97 (3.17)
Extraversion	10.88 (3.98)	11.47 (4.54)
Neuroticism	10.65 (4.59)	10.78 (3.95)
Lie	3.45 (1.48)	2.77 (1.53)*
Enjoyment of physics at O-level	31.38 (4.14)	32.04 (4.41)
Planned 'method' teaching	27.85 (3.27)	26.60 (3.99)
Notemaking, syllabus coverage teaching	17.28 (2.68)	17.35 (2.10)
Pupil-initiative teaching	16.20 (2.57)	16.00 (2.69)
A-level teaching 'match'	20.10 (5.23)	17.40 (5.56)*
Enjoyment (pre-test)	21.50 (5.68)	26.23 (4.30)**
Enjoyment (post-test)	25.40 (5.56)	21.28 (5.47)**
Easiness (pre-test)	9.83 (3.46)	11.30 (2.96)*
Easiness (post-test)	11.73 (3.52)	11.35 (3.84)
Sex	25 boys 15 girls	64 boys 14 girls

** $p < 1\%$; * $p < 5\%$ (t-test, but χ^2 for 'sex')

Table 9.2.4 shows that a whole range of attainment and attitudinal variables have no significant variation between the two groups. The only exceptions are the 'match' and 'lie' variables. The former measures how well the actual classroom environment matches the student's needs. In this instance, enjoyment gain is most likely to be found in the more well-matched classrooms. Earlier in Section 7.2, it was shown that high lie scores could well be measuring strong social conformity. Hence, a tentative interpretation is that students who have the more highly developed code of organised social behaviour are most likely to show enjoyment gains.

Group A students initially display only moderate enjoyment and find the course difficult. However, by the end of the course this group find the subject no more difficult than the now disenchanted students of group B.

The directions of some of the differences in table 9.2.4 are such as to suggest that significance might be reached with a larger sample. These differences imply that group A students are of higher ability than those of group B, have the better study methods, and are more likely to be taught by the planned, logical, 'method' approach.

9.2.3. CORRELATION WITH FIFTH-FORM ENJOYMENT

Physics enjoyment scores in the fifth-form (Section 5.2) were correlated with the sixth-form pre-test and post-test enjoyment scores as shown in table 9.2.5.

TABLE 9.2.5. ENJOYMENT CORRELATIONS BETWEEN YEARS

Variable	Correlation between variable and fifth-form physics enjoyment		
	All (N=124)	Boys (N=92)	Girls (N=32)
Sixth-form enjoyment (Pre-test)	0.28*	0.20	0.49**
Sixth-form enjoyment (Post-test)	0.17	0.12	0.45**
Residual gain in sixth-form enjoyment	0.02	0.02	0.18

** $p < 1\%$, * $p < 5\%$

At the start of the sixth-form course, for the girls, it is seen that there is a 'carry-over' from the fifth-form with a tendency for enjoyment scores to reflect earlier attitudes. This association persists through the whole sixth-form course. On the other hand, boys sixth-form attitudes show no significant correlation with those in the fifth-form.

There is no significant connection between attitude change in the sixth-form and fifth-form enjoyment.

9.2.4. 'PREDICTING' ATTAINMENT GRADES FROM ATTITUDE SCORES

Using A-level physics grades, scored on a seven-point numerical scale (A ≡ 7, B ≡ 6, etc.) as the attainment criterion, simple and multiple correlation techniques were used to investigate the association with the attitude scale items.

TABLE 9.2.6. ATTAINMENT CORRELATES

Scale (post-test)	Boys (N = 108) Beta weight	Boys (N = 108) Simple correlation between score and grade	Girls (N = 35) Beta weight	Girls (N = 35) Simple correlation between score and grade
Enjoyment (composite)	0.23*	0.27*	0.31	0.24
Easiness (composite)	0.26*	0.33*	0.18	0.03
Presentday theories are considered only	-0.10	-0.06	-0.09	-0.22
High prestige	0.04	0.09	-0.22	-0.19
Social implications always considered	-0.09	-0.05	-0.25	-0.10
Makes you think deeply about your personal views	0.03	0.07	-0.26	0.03
Out-of-date	0.09	0.04	-0.32	-0.36*

*p < 5%

The multiple correlations between the real A-level grade scores and those predicted from the multiple regression equations are 0.41 for the boys and 0.53 for the girls.

It is clear that the attitude-attainment pattern for the A-level physicists differs from the O-level one two years earlier (Section 7.2). No longer for the girls is enjoyment associated with attainment, but girls do appear to perform better in the more modern courses. At O-level, subject enjoyment was associated with boys' attainment, too. This relation still holds at A-level.

A more detailed analysis of the attitude-attainment association appears in Section 9.5. The multiple-regression technique, which supposes a particular linear association between a range of variables is equally applicable to all types of pupil, is most satisfactorily applied only after the pupil-types have been identified (Section 2.9). Once this typological analysis has been performed, it becomes clear that for some groups the attitude scale scores display strong correlation with A-level attainment.

9.2.5. THE INFLUENCE OF THE G.C.E. BOARD

The sixth-form courses were spread across five G.C.E. boards. The syllabus content of the boards does not differ greatly, but aims and objectives, either explicitly stated or implicit in past examination papers, are arguably of sufficient variability to differentially affect attitudes and attainment over the duration of the course. To investigate the possible influence of the G.C.E. board factor, the post-test attitude scores and A-level physics grade score were analysed by board.

Taking the earlier demonstrated sex-differences in attitudes into account means that the breakdown has to be in terms of both board and sex. Enjoyment of physics prior to entry to the sixth-form has been shown to have an association with A-level attitudes, at least for girls (Table 9.2.5). In addition, fifth-form enjoyment has some association with attainment in O-level physics (Section 7.2). Thus, it was felt necessary to control for the variation in sixth-form scores due to possible O-level attitude and attainment influences. The breakdown was performed as an analysis of co-variance with the two O-level variables as covariates (Section 2.9). The ANOVA sub-program of the S.P.S.S. system was used (Kim and Kohout, 1975b).

Table 9.2.7 shows just those variables of the sixth-form attitude scale which produce significant variation(at the 5% level) across the boards or between the sexes.

In terms of enjoyment, the London course receives the most favourable rating. Paradoxically, it receives the highest 'difficulty' rating.

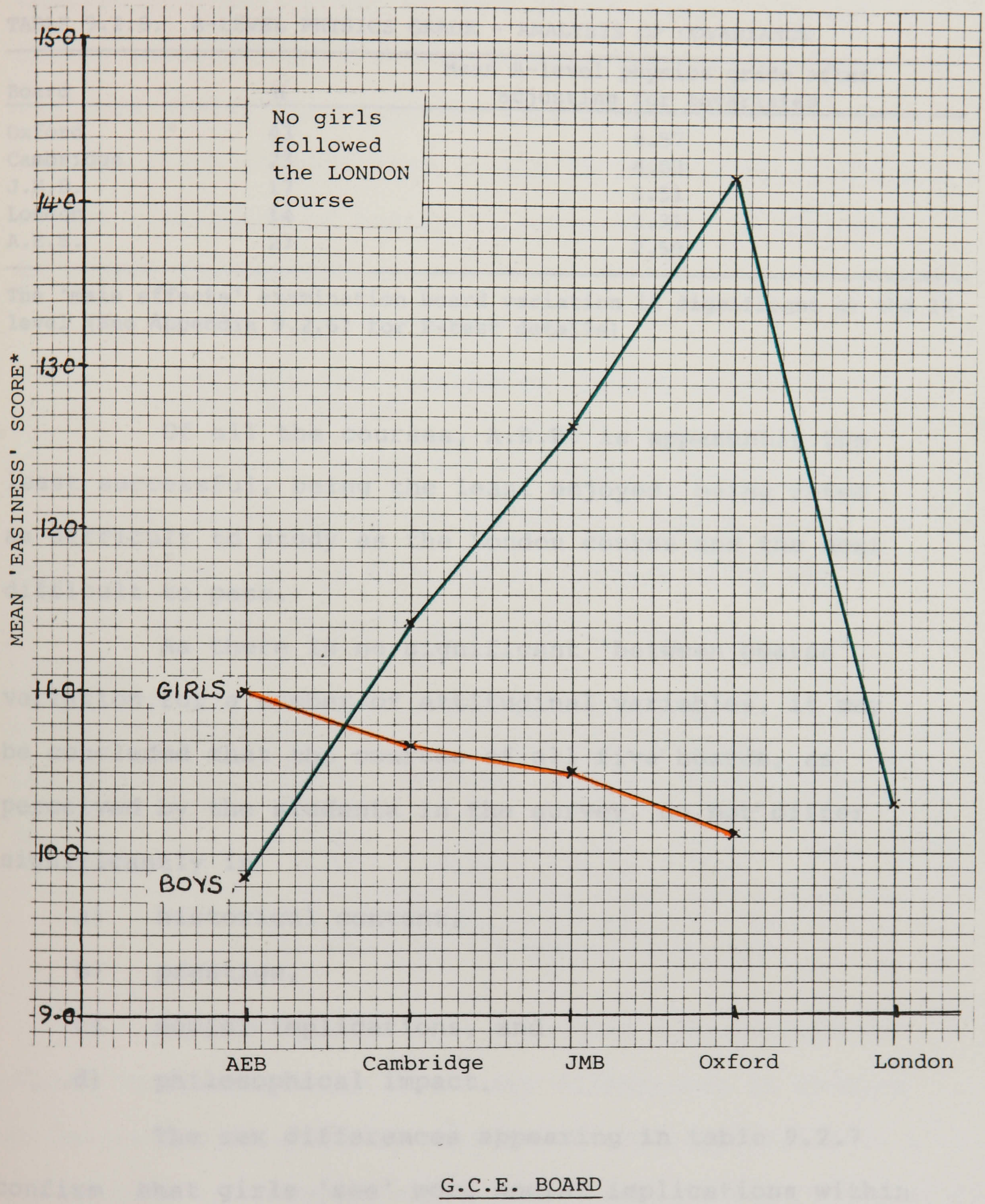
Another course attracting an extreme response is the Oxford one. It is rated the least difficult but also the least modern of the five. The relative easiness of the Oxford course is confirmed by an analysis of covariance performed on the G.C.E. A-level physics grade scores. Adjusting for different student achievement at fifth-form level by making O-level physics grade a covariate, and still controlling for O-level enjoyment, table 9.2.8

TABLE 9.2.7. POST-TEST ATTITUDE VARIABLES - ANALYSIS OF CO-VARIANCE

Attitude variable	ANOVA result if significant (5% level)	Breakdown of scores (adjusted)		
Enjoyment* (composite)	Variation across boards	London	(N=14)	26.65
		J.M.B.	(N=17)	23.87
		Oxford	(N=43)	22.68
		Cambridge	(N=23)	22.19
		A.E.B.	(N=27)	20.47
Easiness** (composite)	Variation across boards	Oxford	(N=43)	12.73
		J.M.B.	(N=17)	12.04
		Cambridge	(N=23)	11.26
		A.E.B.	(N=27)	10.07
		London	(N=14)	10.06
	Variation between sexes	Boys	(N=92)	12.05
		Girls	(N=32)	10.41
	Variation due to board-sex interaction	Girls rate the A.E.B. course the easiest and the Oxford one the most difficult. Boys rate these two courses exactly oppositely (see figure 9.2.1.)		
Social implications always considered***	Variation between sexes	Girls	(N=32)	3.82
		Boys	(N=92)	3.13
Out-of-date ***	Variation across boards	Oxford	(N=43)	3.63
		J.M.B.	(N=17)	3.47
		A.E.B.	(N=27)	3.13
		Cambridge	(N=23)	3.13
		London	(N=14)	2.40
	Variation between sexes	Boys	(N=92)	3.35
		Girls	(N=32)	2.76

* Scores range from 5 to 35 with 20 indicating a neutral response
** Scores range from 4 to 28 with 16 indicating a neutral response
*** Scores range from 1 to 7 with 4 indicating a neutral response
Appendices 9.2.2. to 9.2.5. give F-test details

Figure 9.2.1 'Easiness' scores - G.C.E. board/sex interaction



*Scores on the 'easiness' scale range from 4 to 28. A score of 16 indicates a neutral response. The lower the score the more difficult the course.

shows that the Oxford A-level examination awards the higher grades (on the seven point scale where 'A' $\geqq$ 7).

TABLE 9.2.8. A-LEVEL PHYSICS GRADE - ANALYSIS OF COVARIANCE

Board	N	Mean A-level physics grade after adjusting for covariates
Oxford	43	4.57
Cambridge	23	4.03
J.M.B.	17	3.51
London	14	3.31
A.E.B.	27	2.59

The 'main effects' examination board variation is significant at the 1% level (See Appendix 9.2.6: for F-test details)

Of all the courses, A.E.B. is apparently the least successful, being the least enjoyed, being rated as difficult to study as the London course and the most difficult to pass.

As there is no significant 'between boards' variation for a number of attitudinal variables, it may be concluded that the courses of all five boards, as perceived by the students in the survey, do not differ significantly in

a) historical content,

b) prestige,

c) social implications, and

d) philosophical impact.

The sex differences appearing in table 9.2.7 confirm that girls 'see' more social implications within the course material and find the course more difficult on the whole (table 5.9.2). In this slightly reduced sample, the girls give the course a higher 'modern' rating.

In discussing the interpretation of adjusted scores from the ANOVA program, Kim and Kohout (1975b) caution against the use of such scores when there are strong interaction effects. However, on the composite easiness scale, the board-sex interaction is only just able to reach significance at the 5% level (Appendix 9.2.3) so the rank-order of boards in table 9.2.7 is assumed to retain some validity.

9.2.6. ATTITUDE AND ATTAINMENT CHANGES ACCORDING TO TYPE OF COURSE

Residual scores for enjoyment, easiness and attainment gains during the sixth-form course (Section 9.2.1) were compared for the five G.C.E. courses using the F-test to test for significance (table 9.2.9).

TABLE 9.2.9. G.C.E. COURSE DIFFERENCES IN RESIDUALS

	Mean residual score					
	A.E.B.	Cambridge	J.M.B.	London	Oxford	'F'
Enjoyment	-1.69	-0.60	-0.12	2.84	0.51	2.35
Easiness	-1.52	-0.14	0.94	-0.95	0.96	3.29*
Attainment	-1.14	0.28	-0.22	-0.27	0.75	8.59**

** p < 1%; * p < 5%
F-test with 4 and 115 degrees of freedom

Apparently, the type of course does not affect change in enjoyment but there are differences in changes in easiness rating and in attainment. However, until appropriate covariate controls are imposed on the calculation of the residuals (Section 2.9) any further inferences might be hazardous. By controlling for these covariates, the variance in the residual scores can be examined to identify that which can be uniquely attributed to the treatment or factor variables (examination board, for instance). A series of covariates can be used, discarding those which fail to account for a significant amount of residual score variance. The S.P.S.S. ANOVA procedure permits up to five covariates in any one analysis.

Covariates were selected from the variables of table 5.1.1. The residual enjoyment, easiness, and attainment scores were taken in turn. Examination board and sex were again the main factors. After several ANOVA runs to isolate the significant covariates in each of the three cases, the results appearing in tables 9.2.10 and 9.2.12 were obtained. The full ANOVA tables are given in Appendices 9.2.7 to 9.2.9.

Table 9.2.10 shows the impact of the five different courses on sixth-form enjoyment scores. Controlling for prior attainment in physics, the perceived easiness of the A-level course and the sixth-form teaching style (as measured on the planned, logical 'method' scale) shows that the London course is much the more effective in maintaining the students initial enjoyment over the two years (Appendix 9.2.10 gives the raw pre-test and post-test enjoyment scores). Comparing the adjusted enjoyment residuals with the less refined statistical treatments of tables 9.2.7 and 9.2.9 indicates that the choice of covariate controls is crucial. Perceived easiness and teaching approach significantly affect enjoyment change: it appears that subject difficulty and a teaching

TABLE 9.2.10. ENJOYMENT 'GAINS' BY COURSE-TYPE

Board	N	Adjusted post-test enjoyment score	Adjusted enjoyment residual	Unadjusted enjoyment residual
London	14	27.68	4.94	2.84
J.M.B.	17	22.89	0.17	-0.12
A.E.B.	27	22.04	-0.68	-1.69
Oxford	43	21.91	-0.81	0.51
Cambridge	23	21.90	-0.82	-0.60

Covariates: O-grade physics; Easiness (A-level); Planned, 'method' teaching (experienced)

TABLE 9.2.11. EASINESS 'GAINS' BY COURSE-TYPE

Board	N	Adjusted post-test easiness score	Adjusted easiness residual	Unadjusted easiness residual
J.M.B.	17	12.40	0.92	0.94
Oxford	43	12.34	0.86	0.96
Cambridge	23	11.30	-0.18	-0.14
London	14	10.53	-0.95	-0.95
A.E.B.	27	10.18	-1.30	-1.52

Covariates: Extraversion; Fear-of-failure

TABLE 9.2.12. ATTAINMENT 'GAINS' BY COURSE-TYPE

Board	N	Adjusted post-test attainment score	Adjusted attainment residual	Unadjusted attainment residual
Oxford	43	4.27	0.52	0.74
Cambridge	23	4.02	0.27	0.28
London	14	3.73	-0.02	-0.27
J.M.B.	17	3.56	-0.19	-0.22
A.E.B.	27	2.81	-0.94	-1.14

Covariates: Extraversion; Easiness; Intrinsic motivation; Notemaking, syllabus coverage teaching (experienced); A-level physics exam. motivation method showing deficiencies in the planned, logical approach have been responsible for the A.E.B. course showing a marked enjoyment deterioration in the earlier analysis. This deduction is confirmed by the correlations of table 9.2.13, where both easiness and teaching style show significant association with the enjoyment residual 'gain'. Table 9.2.10 now demonstrates that the A.E.B. course differs little from those of Oxford and Cambridge in its ability to sustain enjoyment scores, and may even be superior in this respect.

The residual analysis, with covariate controls, for the changes in easiness rating, table 9.2.11. shows only minor differences to those reported in table 9.2.9. for residuals alone. The covariate controls of introversion and fear-of-failure, although making significant contributions to the residual variance have relatively little effect on the rank order of courses. Comparing with the earlier results of table 9.2.7., it is notable that there is no longer any significant sex differences when the residual analysis is used (Appendix 9.2.8).

The evidence from table 9.2.12 is that after controlling for significant student attitudes, personality, teaching methods (the notemaking, syllabus-coverage style) and the perceived easiness of the course (in part a measure of student ability), it is still easier to get a high grade in the Oxford G.C.E. examination than it is in the A.E.B. examination. This is a repetition of the findings from the earlier, simplified analyses of tables 9.2.8 and 9.2.9. The imposition of the covariate controls is seen to reduce the apparent easiness of the Oxford examination but to affect the London examination in the opposite sense.

9.2.7. SOME FURTHER COURSE DIFFERENCES : A CORRELATION BREAKDOWN

The choice of covariates has been made from those variables which showed an overall significant association with the residual scores. The cluster analysis of Section 9.5. illustrates the differential 'treatment' effects for the five student groups and the respective outcomes. This suggests that the student 'types' might respond differently to the five G.C.E. courses : the physics 'intellectuals' of type II, for instance, responding particularly to one of the courses and displaying significantly better attainment and enjoyment. Consequently, the ANOVA procedure was repeated for each student cluster, using a set of covariate controls for the residuals particular to that cluster and selected from Section 9.5. as being likely to affect the residual 'gains'. In the event, no significant cluster differences could be found, possibly because of the small sub-cell numbers. Thus, the course differences revealed and confirmed in this Section must, on the evidence of the present research, be assumed to be characteristic of sixth-form physicists generally rather than of one or more student stereotypes.

Before leaving the problem of variation across courses, simple correlation coefficients were calculated for each course to compare unadjusted residual scores with the covariate variables (tables 9.2.13 and 9.2.14.).

TABLE 9.2.13. RESIDUAL ENJOYMENT 'GAINS'-
COVARIATE CORRELATIONS BY COURSE-TYPE

Board	Correlation between unadjusted residual score and: O-grade physics	Easiness (A-level)	Planned 'method' teaching (experienced)
A.E.B.	0.23	0.63**	0.43*
Cambridge	0.49*	0.42*	0.28
J.M.B.	0.55*	0.18	0.23
London	0.45	0.11	-0.04
Oxford	-0.04	-0.08	0.21

** p < 1%; * p < 5%

TABLE 9.2.14 RESIDUAL ATTAINMENT 'GAINS'-
COVARIATE CORRELATIONS BY COURSE-TYPE

Board	Correlations between unadjusted residual score and: Extraversion	Easiness	Intrinsic motivation	Notemaking syllabus-coverage teaching (experienced)	A-level physics exam. motivation
A.E.B.	0.02	0.14	0.09	-0.18	-0.23
Cambridge	-0.24	0.25	0.34	-0.42*	-0.31
J.M.B.	-0.17	-0.02	0.20	0.15	-0.28
London	-0.44	-0.24	0.48	-0.24	-0.14
Oxford	-0.43**	0.31*	0.12	0.13	0.00

** p < 1%; * p < 5%

Reference has already been made to table 9.2.13. Students whose enjoyment deteriorates when following the A.E.B. course are most likely to be finding the course difficult and receiving little of the planned, logical 'method' teaching. Students on the J.M.B. and Cambridge courses are likely to maintain an enjoyment 'gain' (or at least, maintain their initial enjoyment) if they have done well at O-level.

No table appears for residual easiness 'gain' as there is only one significant correlation. This is for the Oxford course, where introverts are most likely to show a 'gain' ($r = 0.37$, $p < 5\%$).

It is the Oxford course which features most strongly in table 9.2.14. Introverts finding the course easy are those most likely to improve upon their level of academic physics achievement in the sixth-form. The notemaking, syllabus-coverage teaching style is clearly associated with a deterioration in academic performance on the Cambridge course.

9.2.8. CONCLUDING REMARKS

The research reported here makes a further contribution to the interest deterioration effect referred to in Section 2.2. Some studies (e.g. Rothman, 1969; Stevens and Atwood, 1978) report gross attitude changes in physics or science without giving details of any breakdown of scores by sex. There is no doubt that in the context of English science education such an omission would be most misleadng. Should the results for pre-test/post-test differences (table 9.2.1.) be presented to disguise the differential sex effect, the conclusion from the current research would have to be that 'enjoyment in physics was found to deteriorate over the two year course'. The correct interpretation is, however, that for boys only is this deterioration generally the case. <u>For the</u>

girls of this sample, physics enjoyment remains unaltered during the sixth-form course and correlates highly with enjoyment of fifth-form physics (table 9.2.5).

Breaking down enjoyment changes over the two-year course by examination board (table 9.2.10) shows that the relative deterioration is variable and deterioration is not inevitable. The course of the London G.C.E. board, which is followed by boys only in this survey, is able to roughly maintain (unadjusted) enjoyment scores at their pre-test level. After adjusting for covariates, post-test scores show an increase. Thus, even within an overall attitude deterioration, it is possible for some groups to at least maintain initial attitudes.

After controlling for specific co-variate variables selected from a wide range of affective and cognitive measures, significant differences still exist between the G.C.E. courses of the various boards. The A.E.B. examination is the most difficult to pass: It is easier to do well in the Oxford examination, and it is easier to maintain subject enjoyment when following the London course. Here is confirmatory evidence that there is some variation in standards across the G.C.E. boards at A-level (Hecker and Wood, 1979; Scott 1975), which might be alleviated at least in part if a 'common-core' approach is adopted by the boards with similar schemes of assessment (Schools Council, 1973). In the area of subject enjoyment, the solution is more elusive as it is not clear from this study what it is in the London course that makes it more enjoyable.

In terms of attainment, the London examination provides 'normal' results, so it is pertinent to suggest that curricular reform in A-level physics should be directed towards a common core of content with a syllabus style and aims similar to that of the present London course (University of London, 1981).

However, one doubt remains concerning the interpretation of the achievement gains. As the students have taken the examinations of different O-level boards, there is the problem of comparability of standards across the boards at this level to consider, too. While it is unlikely that the majority of students will have acquired grades which depend upon the awarding board, there is evidence of varying standards in the awarding of grades (Nuttall et al., 1974) which will cause some students of similar physics ability to be awarded a grade B by one board and a grade C by another. This problem of a lack of a uniform grading scale at the O-level stage means that achievement trends appearing over the sixth-form course must be viewed with some caution. The development of the new '16+' examination (T.E.S., 1978) with, perhaps, a common-core element of subject content assessed by objective tests would more readily assist the achievement of comparable standards and a reliable attainment base for sixth-form research.

No distinction between the courses of the G.C.E. boards has been found in terms of historical content, social implications or philosophical impact, unlike in the North American study of Ahlgren and Walberg. What has been demonstrated in this respect is that for both boys and girls, and especially for the latter, physics enjoyment is significantly related to the degree of philosophical impact of the course on the student. Ahlgren and Walberg found a weak association between philosophical impact and interest but did not give separate correlations for boys and girls. Another similar finding of the two studies is that the easier a course is rated, the more likely it is to be enjoyed. The North American study gives no sex breakdown, but the evidence from the present research is that this is more strongly a masculine characteristic. Both studies also demonstrate the highly mathematical perception of the physics course: both have found no association between this perception and course enjoyment or interest.

However, from the factor analysis of table 5.9.3 , it is clear that subject difficulty is strongly associated with a mathematical emphasis to the A-level course. As A-level physics teachers tend to demand a certain mathematical expertise from their students (Holley, 1974), the results of the present survey suggest that an over-emphasis of mathematics would do little to make the subject easier.

Positive subject attitudes tend to be reflected in higher subject grades at A-level for the boys, just as they did at the O-level stage. Creating a learning environment and atmosphere that encourages such attitudes to develop appears to support higher achieving boys. The nature of this environment, and whether it is the same for all types of student, is explored in Sections 9.4. and 9.5. The girls at A-level, in showing no significant association between enjoyment and attainment, confirm their relative unique characteristics in this traditionally male subject.

9.3. THE INFLUENCE OF MOTIVATION AND STUDY HABITS

9.3.1. SEX DIFFERENCES ON THE S.S.R.C. SCALES

The mean scores for boys and girls on each of the six S.S.R.C. scales (Section 5.10) were compared and the statistical significance of the differences investigated (Table 9.3.1) .

TABLE 9.3.1. BOYS' AND GIRLS' DIFFERENCES IN MEAN SCORES

Scale	Mean scores (standard deviation)	
	Boys (N = 108)	Girls (N = 35)
Academic achievement motivation	13.01 (3.38)	13.51 (2.29)
Organised study habits	19.26 (4.68)	22.23 (5.75)**
Fear of failure	10.43 (3.08)	11.49 (3.02)
Syllabus boudness	12.88 (3.09)	12.40 (2.96)
Extrinsic motivation	13.57 (2.58)	13.14 (3.09)
Intrinsic motivation	9.30 (3.27)	11.06 (2.80)**

** $p < 1\%$ (t-test)

The girls are seen to have the more organised study habits and to have the higher intrinsic motivation.

Table 9.3.2 shows the inter-correlations between the scales for the 108 boys (above the diagonal) and 35 girls (below the diagonal).

TABLE 9.3.2. SCALE INTER-CORRELATIONS BY SEX

	Academic achievement motivation	Organised study habits	Fear-of-failure	Syllabus bound-ness	Extrinsic motivation	Intrinsic motivation
Academic achievement motivation		19*	13	-16	14	37**
Organised study habits	-13		-33**	-16	09	17
Fear-of-failure	-08	-24		14	00	16
Syllabus boundness	04	-37*	10		11	-28**
Extrinsic motivation	10	-37*	-06	21		05
Intrinsic motivation	-06	07	39*	-38*	-40*	

** $p < 1\%$; * $p < 5\%$. Decimal points are omitted

Generally, the intrinsic motivation and organised study habits scales feature in the strongest associations.

For girls only, syllabus boundness is related negatively to good study habits. Girls with poor study habits presumably welcome the structure of syllabus-bound classes. It is interesting to see that girls who have a strong intrinsic motivation are more likely to be affected by a fear-of-failure, while at the same time rejecting the apparent security that syllabus-boundness might be expected to give.

Other relationships peculiar to the girls are the negative ones between extrinsic motivation and study habits and between extrinsic and intrinsic motivation. Girls with high scores on extrinsic motivation are likely to have poor study habits and low intrinsic motivation.

Notable male associations are between

a) academic achievement motivation and study habits
b) academic achievement motivation and intrinsic motivation, and
c) fear-of-failure and study habits (negative).

Boys motivated by competitive academic achievement are likely to have good study habits and a high intrinsic motivation. Poor study habits accompany high fear-of-failure ratings.

There is just one relationship which holds for both boys and girls: high intrinsic motivation scorers tend to be 'syllabus free'. In other words, students who are motivated by the intellectual nature of the subject are unlikely to be attracted by excessively prescriptive direction by their teacher. Such students tend to work along their own more flexible lines of enquiry rather than follow an excessively structured course.

9.3.2. CORRELATES WITH ATTAINMENT

Grades in the A-level examination were converted into 7-point scores. A mean attainment score was then calculated from

$$\frac{\text{total subject point score}}{\text{number of subjects taken}}$$

As a measure of achievement upon entering the sixth form, the number of G.C.E. O-level passes was entered, initially, with the S.S.R.C. scale scores into the regression analysis, which used mean A-level attainment as the criterion variable.

Tables 9.3.3 and 9.3.4 report which of the variables most strongly influence attainment at A-level for boys and girls, respectively.

TABLE 9.3.3. VARIABLES AFFECTING ATTAINMENT - BOYS

Variable	Beta-weight	Simple correlation between variable and attainment
Number of O-level passes	0.36*	0.41*
Intrinsic motivation	0.17	0.24*
Academic achievement motivation	0.14	0.29*
Organised study habits	0.13	0.25*
Extrinsic motivation	-0.07	-0.05
Fear-of-failure	-0.06	-0.12
Syllabus-boundness	-0.03	-0.16

* p < 5%

TABLE 9.3.4. VARIABLES AFFECTING ATTAINMENT - GIRLS

Variable	Beta-weight	Simple correlation between variable and attainment
Fear-of-failure	-0.46*	-0.52*
Number of O-level passes	0.37*	0.50*
Extrinsic motivation	-0.30*	-0.26
Syllabus-boundness	0.22	0.06
Academic achievement motivation	0.20	0.23
Intrinsic motivation	0.13	-0.13
Organised study habits	-	0.11

* $p < 5\%$

Using all the variables to set up regression equations to predict attainment leads to multiple correlations of 0.52 and 0.74 for boys and girls, respectively. Mainly due to the outstanding contribution of the 'fear-of-failure' variable to the prediction of academic attainment for the girls, the attitude scales are seen to be better predictors for girls than for boys.

The dominance of fear-of-failure requires further comment. Girls whose motivation is influenced by feelings of self-doubt and uncertainty are likely to achieve the poorer A-level results. The other negative variable is extrinsic motivation: the need to be successful for external reasons, which also has an association with poor attainment. There is evidence here of a <u>fatalistic inevitability about some girls' performances</u>. Those who have self-doubts about their ability to succeed at A-level, and who are being carried along by external rather than internal forces, have in the final event their uncertainties confirmed and, most likely, their external plans frustrated.

The attitude-attainment relation for boys, on the other hand, appears to be much more clear cut. A-level success is strongly associated with prior academic ability, as measured by O-level performance. Intrinsic and academic motivation are factors too, but are of relatively low importance.

When the regression analysis is repeated for the boys with the 'number of O-level passes' variable excluded, just 'academic motivation' and 'organised study habits' make significant contributions to the regression equation with beta-weights of 0.23 and 0.14, respectively (Appendix 9.3.1). The analysis for the girls under these circumstances confirms the importance of 'fear and failure' and 'extrinsic motivation', which dominate the regression equation with beta-weights of -0.56 and -0.28, respectively. Multiple correlations with A-level attainment scores are now 0.39 and 0.66 for boys and girls, respectively.

9.3.3. DISCRIMINATING BETWEEN SUCCESS AND FAILURE

The criterion of academic success was taken once more to be the mean subject point score. For both boys and girls, two extreme achieving groups were selected: one corresponding to mean grades A to C and the other to mean grades E, O and F. Table 9.3.5 shows the distribution of boys and girls amongst these two grade groups. For completeness, the remaining achievement group, grade D, is shown too.

TABLE 9.3.5. GRADE GROUP COMPOSITION

Grade group	Number of boys	Number of girls
A, B, C	28	18
E, O, F	53	6
D	27	11

The girls are most strongly represented in the high achieving group with the boys in the majority in the low achieving E,O,F group ($p<1\%$, χ^2-test)

Using the S.P.S.S. Discriminant procedure (Section 2.9), the S.S.R.C. scale scores were used to construct composite discriminant functions which showed the maximum variation between the two extreme pass groups. The analysis was conducted separately for each sex.

Table 9.3.6 shows the breakdown of scale scores by grade group.

TABLE 9.3.6. GRADE GROUP MEANS

	Mean score on S.S.R.C. scale					
Grade group	Fear-of-failure	Syllabus-boundness	Organised study habits	Intrinsic motivation	Extrinsic motivation	Academic achievement motivation
A,B,C (boys)	9.89 (2.30)	12.04 (3.34)	21.04 (4.63)	10.96 (3.83)	12.96 (2.41)	14.11 (3.00)
E,O,F (boys)	11.09 (3.34)	13.34 (3.01)	18.34 (4.43)	8.70 (3.00)	13.40 (2.70)	12.04 (3.38)
A,B,C (girls)	10.22 (2.44)	12.56 (2.79)	21.89 (5.60)	10.72 (3.20)	13.00 (2.89)	14.28 (2.11)
E,O,F (girls)	14.50 (2.66)	12.17 (3.97)	16.83 (4.54)	12.50 (1.76)	15.00 (2.37)	14.00 (1.41)

Standard deviations are shown in brackets

For the boys, a single discriminant function, which is expressed by the standardised coefficients of table 9.3.7 accounted for all the variance in the variable scores. A different function accounted for all the variance in the girls' scores.

TABLE 9.3.7. DISCRIMINATING BETWEEN A-LEVEL ACHIEVEMENT GROUPS

Boys analysis		Girls analysis	
Variable	Standardised discrimination coefficient	Variable	Standardised discrimination coefficient
Intrinsic motivation	0.62	Fear-of-failure	0.97
		Extrinsic motivation	0.66
Academic achievement motivation	0.57	Syllabus-boundness	-0.65
		Organised study habits	-0.49
Fear-of-failure	-0.54	Academic achievement motivation	-0.37
Mean score A-B-C group	0.65	Mean score A-B-C group	-0.68
Mean score E-O-F group	-0.34	Mean score E-O-F group	2.04

The boys' discriminatory function is seen to be 'academic scholarship' - motivation to study academic subjects for their own sake and the feedback of intellectual mastery, accompanied by a lack of a fear-of-failure. Using this function to classify the boys into their respective achievement groups results in a 67% correct allocation.

The function obtained from the girls analysis yields a 92% correct classification: just two of the 24 girls are misplaced by the discriminant equation. The discriminatory function for the girls is 'impending doom'. Girls who are haunted by the prospect of failure, and whose need for success is dominated by external, career and parental, criteria are the ones whose academic results are poorest.

9.3.4. THE ASSOCIATION WITH PERSONALITY AND PRIOR ATTITUDES

Table 9.3.8 compares scores on the S.S.R.C. scales with fifth-form measures of personality and attitude (Sections 5.3 and 7.3). Fifth-form scores were not available for all students.

In the progressive development of the S.S.R.C. scales from the early Rowntree measures (Sections 2.5 and 5.10.1) the study-habits scale has retained substantially the same psychological base. This has not been so with the motivation scales, as different dimensions in motivation al meaning have been explored. There is some evidence for these shifts in scale development from the correlation matrix of table 9.3.8.

TABLE 9.3.8. CORRELATION BETWEEN MOTIVA TION AND STUDY ATTITUDES AT FIFTH- AND SIXTH-FORM LEVELS

Fifth-form attitudes and personality		Sixth form attitudes					
		Academic achievement motivation	Organised study habits	Fear-of-failure	Syllabus-boundness	Extrinsic motivation	Intrinsic motivation
Academic motivation	boys	0.18	0.07	0.06	-0.27*	0.00	0.15
	girls	0.20	-0.01	-0.12	-0.25	-0.24	-0.02
Organised study habits	boys	0.08	0.24*	0.04	-0.35**	0.09	0.17
	girls	-0.13	0.62**	0.11	-0.09	-0.27	0.06
Extraversion	boys	0.04	0.01	-0.14	0.25*	0.21*	-0.14
	girls	0.13	0.22	-0.09	-0.26	-0.10	0.17
Neuroticism	boys	0.10	-0.13	0.22*	0.15	0.15	0.11
	girls	0.09	-0.11	-0.15	-0.03	-0.19	0.11
Lie	boys	-0.07	0.12	-0.03	-0.21*	-0.09	0.17
	girls	-0.08	0.33	0.10	0.05	-0.13	0.00

** $p < 1\%$; * $p < 5\%$

Study habits for both boys and girls are seen to correlate at the fifth- and upper sixth-form level. While this might seem unsurprising, the time available for reflection and more mature thought in the sixth-form might be expected to be used by those students with the poorer methods of study in the fifth-form to improve their study techniques. Thus, although students with good habits at O-level would be expected to maintain these, those with the poorer habits would be expected to improve, and, as it would be unlikely that study methods would deteriorate markedly, an overall positive correlation is to be expected, but not necessarily a high one.

Fifth-form and sixth-form motivation show no significant inter-correlation. The two academic motivation scales contain a number of common items, but nevertheless, the two year period between testing is sufficient to allow for some substantial shifts in attitude. A successful, well motivated student at O-level could find progress towards A-level more elusive. In consequence, motivation scores might be depressed as the sixth-form course draws to a conclusion, which reveals itself as an insignificant academic motivation correlation. The drive to succeed through either internal or external motivation is not measured by the fifth-form scale and a significant correlation was not expected.

The nature of the fear-of-failure scale, with its underlying anxiety construct, strongly suggests that fear-of-failure motivation scores will correlate positively with neuroticism as measured on the Eysenck scale. It is surprising to find just a weak correlation for the boys and the absence of any correlation at all for the girls. A partial explanation might be the unreliability of the personality measure which was made at the fifth-form level, two years before the fear-of-failure test. Published information on the Eysenck scale points to a fall in neuroticism (and extraversion) scores with age, although this fall is insignificant over a period of one year (Eysenck and Eysenck, 1964). Until further data is available on the nature of personality change over time, any explanation of the fear-of-failure association must remain speculative.

The implications of high syllabus-boundness scores for girls has been referred to earlier (p.488). From table 9.3.8, it is clear that there are no personality associations for the girls, but, for the boys, syllabus-boundness appears to be related to extraversion. As it is the 'freedom' pole of the syllabus-boundness scale which seems to characterise students with desirable attributes (introversion, intrinsic motivation and for girls, good study habits) in the present survey, the criticism made by Entwistle et al. (1974) of the pre-S.S.R.C. syllabus-boundness scales is probably justified. For, as it has been pointed out in Section 2.5 , several earlier studies revealed that syllabus-boundness was almost a pre-requisite for success in science.

The negative, though weak, association between the Eysenck Lie scale scores and syllabus-boundness for boys implies that pupils with high social conformity attitudes (high lie scores - Section 7.3.3 and Eysenck and Eysenck, 1976) are likely to be syllabus-free. This is another finding in conflict with previously published results. Hudson (1966, 1968) has reported that sixth-form science students are more compliant with authority than other student groups and tend to be more syllabus-bound. However, as Hudson used a survey sample comprising boys from highly selective grammar schools and public schools, his results cannot necessarily be generalised to the comprehensive sixth-forms of a decade later.

9.3.5. CONCLUDING REMARKS

The results obtained in this sixth-form survey show that the S.S.R.C. scales maintain their reliability when used with a slightly younger population. The study habits and intrinsic motivation scales appear to be the most stable. No attempt has been made to establish validity in the present survey and evidence of this is awaited from the major S.S.R.C. project. Nevertheless, with the larger boys' sample, positive association has been demonstrated between A-level academic success and scale scores on (a) intrinsic motivation (b) academic achievement motivation and (c) organised study habits. The positive attainment correlates for the girls are low fear-of-failure and low extrinsic motivation. Overall, the magnitudes of the associations between attainment and motivation are consistent with those obtained from other science learning studies (Kremer and Walberg, 1981), although a sharper analysis has emerged from the more precisely defined motivational dimensions.

Motivation through fear-of-failure plays a strong part in discriminating between levels of achievement for the girls. The direction of the discrimination, with high fear-of-failure scorers getting low grades, confirms the earlier work of Weiner (1972). These girls may well be reacting to the sex typing of science referred to in Section 2.4. After all, girls are not expected to be studying A-level physics according to conventional social practice, so those that make only modest academic progress are faced starkly with their somewhat isolated position, which re-inforces their fear-of-failure. This social interpretation of the influence of fear-of-failure, for the girls, is given support by the lack of any association between fear-of-failure and anxiety, although anxious boys do display this form of motivation.

Since this research was completed, the first reports on the use of the S.S.R.C. scales in higher education have been made available (Entwistle et al., 1979; Ramsden and Entwistle, 1981). Factor analyses of all twelve S.S.R.C. scales, course perception scales and attainment variables yielded an achievement factor to which the intrinsic motivation,low fear-of-failure and organised study habits variables were related. This factor is similar to the 'academic scholarship' function which was able to distinguish high achieving boys in table 9.3.7.

The present research shows that there is no significant association between syllabus-boundness and fear-of-failure. The conflict with the findings from higher education (Entwistle, 1977 ; Ramsden and Entwistle, 1981), where fear-of-failure is likely to drive students into syllabus-boundness, possibly reflects the different survey populations. Sixth-form physics students are more likely to demonstrate low intrinsic motivation and, if girls, poor study habits, too, in association with syllabus-boundness. The definition of the latter suggests that students demonstrating this characteristic could be 'surface processors' (Ramsden and Entwistle), in which case the teaching of study-skills and thinking strategies to sixth-formers might lessen the need for the syllabus- bound/ surface processing approach to be adopted, and might possibly strengthen intrinsic motivation.

However, it is necessary to investigate the interaction between the nature of the learning-strategy adopted in the sixth-form and academic achievement. The evidence from this survey, restricted to A-level physics, where the girls form a somewhat unusual proportion of the population (Head, 1979) possibly untypical of female sixth-formers generally, is that there might be some important sex differences in the effectiveness of learning-strategies. It also needs to be demonstrated that surface processing/ syllabus boundness, in comparison with deep-level thinking/ syllabus freedom, <u>is</u> detrimental to learning and achievement in the sixth-form. While success in all areas of higher education might demand the mastery of sophisticated thinking skills (Entwistle, 1977 , and more recently confirmed by Ramsden and Entwistle), it remains to be seen to what degree such a mastery influences A-level attainment for the different sixth-form student types.

Further research is readily suggested and for girls, at least, is highly desirable. A larger sample, chosen specifically for a 'sixth-form thinking strategy' project is required. The 'surface' and 'deep-level' processing scales should be added, together with the Eysenck test to obtain concurrent personality data. Using an unrestricted upper sixth-form population, a breakdown analysis across subject areas would be permitted using

G.C.E. A-level performance and higher-education specialism area as criterion variables. The results of such an extensive project would complement the S.S.R.C. university study and hopefully improve the quality of learning in school sixth-forms.

9.4. PERCEPTIONS OF THE CLASSROOM ENVIRONMENT IN THE UPPER SIXTH-FORM

9.4.1. MATCH AND MISMATCH ON THE THREE PREFERENCE SCALES

Scores on the three student preference scales (Section 5.11.4.) were compared with degree-of-use scores on the corresponding items which made up the scales. The match of student preference with reality is shown in table 9.4.1.

TABLE 9.4.1. MEAN SCORES ON THE THREE MAJOR SCALES

Scale	Number of items	Mean score per item (Standard deviations in brackets)	
		boys (N=108)	girls (N=35)
1 Planned 'method' teaching			
a) preference	13	2.70 (0.25)	2.76 (0.16)
b) reality	13	2.06 (0.40)**	2.23 (0.24)**
2 Notemaking/syllabus coverage			
a) preference	10	1.79 (0.36)	1.77 (0.30)
b) reality	10	1.74 (0.25)	1.71 (0.22)
3 Pupil-initiative teaching			
a) preference	8	2.22 (0.32)	2.26 (0.36)
b) reality	8	1.97 (0.33)**	2.04 (0.33)**

** $p < 1\%$ (correlated t-test)
Significant differences between the two forms of a scale are indicated.
There are no significant sex differences
1(a) mean > 2(a) and 3(a) means ($p < 1\%$, correlated t-test)

Differences between the received and preference teaching environments have been pointed out in the commentary accompanying the check-list of items in Section 5.11.1. In terms of the three identified areas of student preference, table 9.4.1 shows the high popularity of planned 'method' teaching with its interesting, multi-media style approach and well integrated practical work. The real classroom activities fall well short of the students' expectations in this area. Pupil-initiative teaching is less attractive, and there is a mis-match here, too. The rather passive, notemaking/quick syllabus coverage method is least popular: both students and teachers (the reality rating) seem to agree on this as there is no significant difference in the mean scores on the two forms of the scale.

9.4.2. MATCH AND MIS-MATCH FOR THE INDIVIDUAL STUDENT

In calculating a 'match' between a preference or intrinsic worth rating on the check-list (table 5.11.1 , scale A) and a degree of use rating (Scale B), the same procedure was used as with the fifth-form preference data (Section 7.4.2). When a student, in responding to a certain check-list item, scored either '1' or '3' on both scales A and B, then a match had been achieved. Over the range of forty items, 'match' scores could vary from 40, a perfect match, to zero.

Once obtained, the match score was then correlated, in turn, with A-level physics attainment (seven point scale), physics enjoyment in the upper sixth-form (Section 5.9) and the degree-of-use versions of the classroom environment scales.

TABLE 9.4.2. CORRELATIONS OF THE 'MATCH' SCORE

	Correlation of match score with				
Sample sub-group	physics attainment	physics enjoyment	planned 'method' teaching (usage)	notemaking/ syllabus coverage (usage)	pupil initiative teaching (usage)
Boys (N=108)	0.16	0.20*	0.49**	-0.05	0.02
Girls (N=35)	0.07	0.11	0.52**	-0.22	0.21

**p < 1%; * p < 5%

Teaching 'match' is seen from table 9.4.2 to have negligible association with physics attainment, but for boys it is positively related to subject enjoyment. For both boys and girls, there is a relatively strong relationship between 'match' and the experience of planned 'method' teaching. The implication, here, is that students whose classroom preferences are satisfied are in classes where the teaching exemplifies the planned , 'method' approach.

Further information on the well matched classes is obtained when correlations are sought between 'match' scores and those item scores from the check-list which do not appear on the three preference scales. Table 9.4.3 shows the 'degree-of-use' items which have significant correlations for the boys.

TABLE 9.4.3. CORRELATIONS BETWEEN NON-ALLOCATED STATEMENTS AND 'MATCH'FOR BOYS

Item	Correlation with 'match' score
4 The teacher guides you in your learning, acting as a source of information, asking questions and using experimental demonstrations to help	0.24*
3 The teacher anticipates the students' problems and sees the subject from their point of view	0.49**
16 You are encouraged to work as an individual rather than as part of a large group of four or more	0.24*
31 Technical terms are used where appropriate, but otherwise the language is every day English	0.32**
38 Regular practice to develop a suitable style in answering exam questions occurs in the second year of the course	0.29**

**p < 1%, * p < 5%

The items in table 9.4.3 could well be added to expand the conceptual meaning of the planned, 'method' scale when interpreting boys' 'match' effects.

For girls, only one of the non-allocated 'degree-of-use' items has a significant correlation with 'match'. A matched environment does not permit elitist teaching.

TABLE 9.4.4. CORRELATIONS BETWEEN NON-ALLOCATED STATEMENTS AND 'MATCH' FOR GIRLS

Item	Correlation with 'match' score
24 The teaching seems to be most suitable for the most able pupils	-0.39*

* p < 5%

9.4.3. CLASSROOM ENVIRONMENT CORRELATES WITH ATTAINMENT AND ATTITUDE

The association between (a) physics attainment and (b) physics enjoyment was investigated by performing multiple regression analyses using attainment and enjoyment as criterion variables (Section 2.9). Independent 'predictor' variables were (i) the three preferences scales, (ii) the remaining eleven preference items from the original 40-item scale A, which were not contained within the three preference scales, (iii) the degree-of-use versions of the preference scales, (iv) the degree-of-use versions of the remaining eleven items (i.e. Scale B responses).

Physics attainment was the A-level grade expressed on a seven point scale. Course enjoyment scores were available from the scales of Section 5.9.

For both attainment and attitudes, the regression pattern was found to be sex dependent. The statements or scales which made significant contributions at the 5% level to the relevant regression equations appear in tables 9.4.5 to 9.4.8.

TABLE 9.4.5. CORRELATES WITH ATTAINMENT - PREFERENCE ITEMS

Sub-group	Item or scale	Beta weight	Multiple-correlation all variables
Boys (N=108)	38 Regular practice to develop a suitable style in answering exam questions occurs in the second year of the course	-0.27	
	24 The teaching seems to be most suitable for the most able pupils	0.25	0.57
	Scale 2: Notemaking/syllabus coverage	-0.23	(0.49)
	7 The teacher uses words rather than mathematics in explanations whenever possible	-0.21	
Girls (N=35)	Scale 1: Planned, 'method' teaching	0.80	
	Scale 3: Pupil-initiative teaching	0.50	0.64 (0.16)

In all tables 9.4.5 to 9.4.8 , the multiple correlations shown in brackets are for the criterion variable and the value resulting from a regression equation comprising just the significant variables.

TABLE 9.4.6. CORRELATES WITH ATTAINMENT - DEGREE OF USE ITEMS

Sub-group	Item or scale	Beta weight	Multiple-correlation all variables
Boys (N=108)	Scale 2: Notemaking/syllabus coverage	-0.29	
	16 You are encouraged to work as an individual rather than as part of a large group of four or more	0.21	0.55
	9 The teacher anticipates the students' problems and sees the subject from their point of view	0.20	(0.40)
Girls (N=35)	9 The teacher anticipates the students' problems and sees the subject from their point of view	-0.45	0.60
	Scale 3: Pupil-initiative teaching	0.41	(0.33)

TABLE 9.4.7. CORRELATES WITH ENJOYMENT - PREFERENCE ITEMS

Sub-group		Item or scale	Beta weight	Multiple correlation all variables
Boys (N=108)	30	The whole syllabus will not be completely covered but the topics taught will have been thoroughly treated	0.32*	0.40 (0.32)
Girls (N=35)	5	Part of the course is devoted to an individual student project	-0.52*	0.70 (0.52)

* Simple r

TABLE 9.4.8. CORRELATES WITH ENJOYMENT - DEGREE OF USE ITEMS

Sub-group		Item or scale	Beta weight	Multiple correlation all variables
Boys (N = 108)	24	The teaching seems to be most suitable for the most able pupils	-0.24	
		Scale 1: Planned 'method' teaching	0.23	
	4	The teacher guides you in your learning, acting as a source of information, asking questions and using experimental demonstrations to help	0.22	0.58 (0.47)
Girls (N=35)	38	Regular practice to develop a suitable style in answering exam questions occurs in the second year of the course	-0.45	
	24	The teaching seems to be most suitable for the most able pupils	0.43	0.72 (0.50)

Table 9.4.5 shows the characteristics of the high achieving students in terms of check-list preference scores. The boys in this category welcome teaching of an 'elitist' nature, directed towards the most able.

They show a preference for a mathematical rather than a verbal approach. The negative influences of the teacher dependent items 38 and scale 2 indicates a certain independence on the part of these boys.

The girls, on the other hand, prefer a planned environment (Scale 1), although the high achievers once more are those who would be prepared to take the initiative in learning situations. The important degree-of-use items for the girls imply that although the teacher does not identify with the needs of the students (item 9.), the girls might still get high grades, presumably because of their initiative capabilities.

Boys who get the highest grades (table 9.4.6) are in classes where there is a lack of emphasis on the note-making/syllabus coverage style but where individualised work is encouraged by a sympathetic teacher (items 16 and 9).

In the enjoyment analyses, fewer items make significant contributions. Boys who enjoy physics the most prefer a thorough, if incomplete syllabus coverage. These boys are likely to receive planned, 'method' teaching with a strong teacher guidance element (item 4, table 9.4.8) where the teaching is not directed towards the most able. Girls would certainly be most unhappy if the course included project work (item 5, table 9.4.7). Positive attitudes are shown by girls in classes which do not practice regularly examination question techniques and where elitist teaching is absent (item 38, table 9.4.8).

9.4.4. CONCLUDING REMARKS

The check-list responses demonstrate that significant differences between pupil preferences and classroom reality exist in the classes of the sample schools. The profile of preferred learning shows many similarities with that identified at fifth-form level (Sections 5.4 and 7.4).

The students' preferences emphasise planned concept learning in a teacher directed environment. The theoretical base for comparison owes most to Gagné's learning theory (Gagné, 1970), and confirms earlier evidence from physics classrooms (Pell 1975, and Section 7.4.4), that pupils' preferences tend to demonstrate the soundness of this aspect of Gagné's work.

The areas of difference, identified for the sample as a whole, show the potential of the check-list method in teacher-based curriculum development. If physics teachers could be encouraged to administer the check-list to their students at the end of the A-level physics course, areas of unsuspected mis-match in their teaching methodology are likely to come to light. This survey has shown that such a mis-match might not influence attainment but that for the boys, at least, there would be a greater chance that they would enjoy the subject.

In a recent review of science learning studies, Fraser and Walberg (1981) argue strongly for the use of pupil preference - reality scales in research studies. They point out that the environment 'match' might be more important than the actual environment in the classroom itself in determining both cognitive and affective outcomes. The results from both fifth-form and upper sixth-form classes in the present study confirm that a matched environment is associated, generally, with superior attitudes but that the only cognitive relationship involves girls at G.C.E. O-level.

The particular deficiences in physics teaching methodology which appear from the present research require careful analysis and consideration by all physics teachers. The pressures of overloaded examination syllabuses (Holley, 1974) and the current limitations, economic and educational (T.E.S., 1981), on traditional sixth form expansion, ask questions of physics teachers concerning the effectiveness of their classroom organisation and behaviour.

Assuming that it is desirable to correct the A-level physics mis-match and expand the provision of planned 'method' teaching, it seems that a possible solution might include:

a) the establishment of locally based physics or science centres, possibly as part of local teachers' centres, linked by the nationally organised Association for Science Education (A.S.E.), and

b) the institution of professional courses for physics teachers at these centres to permit the development of the curriculum skills necessary to implement planned, 'method' type teaching. It would seem that the development of sixth-form and tertiary colleges (T.E.S., 1981) could be a strong factor in solving the A-level physics mis-match problem. The science department of such would be its own local 'science centre'. Within such a department, an occasional team-teaching approach would permit all the lectures and demonstrations, the multi-media techniques, the outside visits, the discussion sessions, and the thorough lesson preparation tasks, to be conducted efficiently, while releasing teachers as appropriate from relatively mundane lesson activities to enable them to renew and re-think their curricular theories.

Attainment correlates in the classroom environment (table 9.4.6) tend to emphasise independent or student initiated activities. The most successful students are those who are capable of working with minimal teacher direction. The preference correlates (table 9.4.5) show that such a state of affairs broadly satisfies the high achieving boys who would be happy with 'elitist', high ability teaching with a mathematical approach. The girls, on the other hand, show a strong preference for planned 'method' learning, with its strong teacher support element in a varied and interesting setting. In reality, the girls do not get the type of learning they prefer, but it is a reflection of their unique personality characteristics in taking this male dominated subject that they are not apparently too upset by this mis-match and adopt the independent style of learning that will give them success under these circumstances.

The clear demonstration that for boys, physics enjoyment is associated with planned, 'method' teaching and overall classroom 'match' confirms some of the findings from the H.P.P. evaluation in the United States (Section 2.6), and answers to some degree the call for students to enjoy science and physics as well as showing academic proficiency (Bondi, 1975). Subsequent discussion, typified by Bausor, 1979, and Trotter, 1980, has been concerned with how this might be done, without much progress being made. The results reported in table 9.4.8 have identified some of the sensitive variables which are under the direct control of the teacher.

Once more, girl physics students show different attitudinal interactions with the classroom environment. Subject enjoyment appears to be unrelated to the major classroom teaching variables but firm conclusions must await the more detailed cluster analysis of Section 9.5.

9.5. STUDENT STEREOTYPES IN THE SIXTH-FORM

9.5.1. DATA TREATMENT

Seven pupil stereotypes in fifth-form physics classes have been described in Section 7.11 , where factor analysis and regression techniques were used to suggest means of maximising pupil attainment and attitudes. Data collected during the sixth-form physics course permitted a similar typological analysis. However, with an expanded range of variables and a reduced sample size of A-level physics specialists, there was a danger that in the various student clusters there would be fewer students than variables, which seriously questions the use of the multivariate regression and factor analysis methods (Youngman, 1979). Consequently, simple correlational procedures were used to identify the more important 'predictor' variables within the identified cluster structure.

9.5.2. THE CLUSTER ANALYSIS

Two computer runs were conducted using the P.M.M.D. clustering program (Youngman, 1975). The second analysis was performed to check the reliability of the clustering procedure, which was achieved by rearranging the data input order. Solutions comprising five or fewer clusters were seen to be stable and independent of the data order (Appendix 9.5.1). The cluster fusion plots (Appendix 9.5.2) showed discontinuities in cluster centroid distances around the four to six cluster levels, which confirmed that the five cluster solution might be the starting point for further analysis (Youngman, 1979).

Table 9.5.1 shows the standardised cluster mean scores on the variables used in the analysis. The P.M.M.D. clustering programme tests each cluster mean for significance against the mean of the remaining scores. Variables showing significant differences are used to identify the cluster.

The variables are described in table 5.1.1 and Appendix 5.1.1 , where references are also given. Two additional variables are those referring to the choice of A-level physics. The 'free choice' variable is a dichotomous score measuring whether A-level physics was chosen freely without any constraint or compulsion (Sections 5.6 and 7.6.4). 'Mathematical and easy' is one of the seven groups of reasons pupils give when choosing A-level physics (Section 7.7.1). Scores for the other six groups of choice reasons have been omitted from table 9.5.1 as they showed no significant differences across the clusters. All seven choice reasons scores were masked from the analysis during the cluster runs.

The two outcome variables of A-level physics grade and post-test enjoyment were not masked from the analysis as the variance in these variables was not to be apportioned by multiple regression as it was in the fifth-form investigation.

The classroom environment variables have been described by code names in table 9.5.1 and subsequent

TABLE 9.5.1. THE FIVE SIXTH-FORM CLUSTERS

	Variable	CLUSTER I (N=34)	II (N=20)	III (N=21)	IV (N=30)	V (N=19)
	SEX	-0.52**	1.24**	-0.93**	-0.51**	-0.59
Attainment	A-level score	0.51**	0.73**	0.44**	-0.91**	-0.74**
	A-Grade physics	0.76**	0.47*	0.33	-0.79**	-0.98**
	O-grade physics	0.51**	0.50	0.04	-0.31	-0.99**
	No.of O-level passes	0.13	0.14	0.51	-0.24	-0.57
Post-test attitudes	Historical	-0.06	0.34	-0.16	0.06	-0.16
	Prestige	0.26	0.04	-0.30	0.16	-0.43
	Social implications	-0.17	0.45	-0.11	0.21	-0.38
	Philosophical	0.21	0.70*	-0.43	-0.02	-0.60
	Modern	-0.27	0.65*	-0.31	0.35	-0.41
	Enjoyment	0.22	0.63*	0.02	0.06	-1.15**
	Easiness	0.65**	-0.45	0.14	-0.14	-0.64*
Pre-test attitudes	Historical	-0.16	-0.01	0.23	0.08	-0.08
	Prestige	-0.11	0.24	0.01	0.26	-0.48
	Social implications	-0.46*	0.74**	-0.19	0.30	-0.22
	Philosophical	-0.32	0.69*	-0.46	0.28	-0.09
	Modern	-0.23	0.27	0.11	0.17	-0.25
	Enjoyment	0.18	0.38	-0.35	0.28	-0.78**
	Easiness	0.58**	-0.17	-0.40	-0.03	-0.36
Sixth-form study and motivation scores	Fear-of-failure	-0.40	0.42	-0.29	0.34	0.06
	Syllabus boundness	-0.12	-0.51	0.06	-0.08	0.56
	Study methods	0.09	0.88**	0.07	-0.31	-0.68*
	Intrinsic motivation	0.26	0.98**	-0.27	-0.33	-0.71**
	Extrinsic motivation	-0.10	-0.67**	0.46	0.32	-0.14
	Academic motivation	0.48*	0.30	-0.15	-0.13	-0.80**
Examination motivation in physics	A-level	0.49**	0.26	0.35	-0.17	-1.27**
	O-level	0.39	0.40	-0.50	0.08	-0.71*
Personality variables	Extraversion	-0.35	-0.13	-0.08	0.25	0.29
	Neuroticism	0.08	0.53	-0.20	-0.21	-0.15
	Lie	0.06	0.47	-0.25	-0.13	-0.13
A-level physics teaching methods	PLANMETH (P)	0.06	0.35	0.06	0.03	-0.59
	PLANMETH (E)	-0.30	0.78**	0.35	0.13	-0.86**
	NOTESYL (P)	-0.54**	0.04	-0.16	0.57**	0.21
	NOTESYL (E)	-0.42	-0.28	-0.02	0.66**	-0.02
	PUPINIT (P)	-0.33	0.20	-0.09	0.27	0.06
	PUPINIT (E)	-0.45*	0.36	-0.15	0.37	0.00
	Matched to pupil needs	-0.08	0.65*	-0.05	0.12	-0.68*
Choice of A-level phys.	Free or pressed	0.30	-0.40	-0.76**	0.46*	-0.00
	Mathematical and easy	0.50*	-0.19	-0.38	-0.04	-0.22
O-level phys. teaching methods	VARUND (P)	-0.32	0.55	0.12	0.14	-0.36
	VARUND (E)	-0.14	0.66*	-0.79**	0.44	-0.25
	Matched to pupil needs	-0.21	0.35	-0.70**	0.46	0.05
O-level attitudes	Physics identification	0.56**	0.38	-1.07**	0.25	-0.62*
	Learning-by-experiment	-0.01	0.16	0.07	0.24	-0.61
	Physics satisfaction	0.17	-0.03	-0.96**	0.60*	-0.17
	Physics 'slog'	-0.72**	0.23	0.61*	0.02	0.34
	Interesting teaching style	-0.18	0.37	-0.54	0.25	0.13
O-level study and motivation scores	Study methods	0.08	0.56	-0.49	0.17	-0.47
	Academic motivation	0.31	0.18	-0.87**	-0.23	-0.16
	Physics study methods	0.16	0.56	-0.67*	0.16	-0.40
	Physics motivation	0.38	0.17	-0.90**	0.30	-0.35

**p < 1%; * p < 5%

tables to permit a more economical presentation of the scores. Table 9.5.2 shows these code names. The fifth-form or O-level variables are coded as in table 7.10.1 earlier.

TABLE 9.5.2. CODE NAMES FOR THE TEACHING METHOD VARIABLES

Variable (table 5.1.1. and Appendix 5.1.1.)	Level	Code Name
15. Varied/teaching-for-understanding (preference)	O	VARUND (P)
16. Varied/teaching-for-understanding (experienced)	O	VARUND (E)
34. Planned, 'method' teaching (preference)	A	PLANMETH (P)
35. Planned, 'method' teaching (experienced)	A	PLANMETH (E)
36. Notemaking, syllabus coverage (preference)	A	NOTESYL (P)
37. Notemaking, syllabus coverage (experienced)	A	NOTESYL (E)
38. Pupil-initiative teaching (preference)	A	PUPINIT (P)
35. Pupil-initiative teaching (experienced)	A	PUPINIT (E)

By inspection of the mean scores in table 9.5.1 , the five clusters are readily identified as meaningful pupil stereotypes. Table 9.5.3 gives additional data to help in the interpretation of the clusters.

9.5.3. CLUSTER I : ABLE, ACADEMICALLY COMPETITIVE, MATHEMATICAL PHYSICISTS.

The standardised SEX score indicates that this is an overwhelmingly male group with just one girl member. The group comprises the most able physics students, as indicated by the high A-level and O-level physics grade scores, but is not the highest achieving group in terms of all-round A-level ability.

Although these students showed a strong allegiance towards and enjoyment of the subject at O-level, A-level course attitudes are not significantly above average.

TABLE 9.5.3. ACHIEVEMENT AND CAREER INTENTIONS FOR THE A-LEVEL STEREOTYPES

Cluster (N)	Number of students achieving					First choice career area								Fifth form pupil stereotype					
	8 or more O-level passes	O-level physics grade A	A-level physics pass	A-level physics passes at grades A or B	3 or more A-level passes	Higher education: Applied Science	Higher education: Pure Science	Higher education: Other	Social	Conven-tional	Enter-prising	Manual	Artis-tic	A_1	A_2	B	D_1	D_{2A}	D_{2B}
I (34)	19	14	31	17	24	24	9							10	21	3			
II (20)	15	10	19	7	17	6	12	1		1				8	10				2
III (21)	20	3	18	4	18	6	10	1		3	1			9	1	6			5
IV (30)	15	2	10		4	16	5		1	1		1	2	9	20	1			
V (19)	8	1	3		3	7	3	1	1	3	1	1	1	7	9		1	1	1

No career area was indicated by six students, one type I, four type IV, one type V

Physics is found to be easy, consistently at both O- and A-level. The significance of the physics choice reasons 'easy and mathematical' suggests that these students are able mathematicians who are adept at using their quantitative problem solving skills in mastering physics.

These students are highly motivated towards the study of academic subjects, expressing particularly strong concern that they should do well in the A-level physics examination.

The only teaching method variable to draw a significant response is that of NOTESYL (P), which is the style where notemaking dominates classroom activities and where the G.C.E. syllabus is covered quickly so that emphasis can be put on preparing for the examination. The students do not prefer this method and are unlikely to experience it.

Inter-relationship between variables

Type I students are very likely to be seeking careers in applied science (table 9.5.3) and are mainly drawn from the A_2-type fifth-formers (Section 7.11.6), whose high ability tend to make them relatively independent of the actual structure of the physics learning environment. To some degree, this environment independence persists through the sixth-form as the correlations of table 9.5.4 indicate. Significant correlations are shown between the two major criterion variables of A-level physics

TABLE 9.5.4. CRITERION CORRELATIONS FOR TYPE I STUDENTS

Variable	A-level physics grade	Variable	Course enjoyment
O-level physics grade	0.51**	Prestigious course	0.50**
Number of O-level passes	0.42*	Learning-by-experiment	-0.44**
Extraversion	-0.38*	Modern course	-0.40*
Philosophical course	-0.38*	Teacher's interesting style at O-level	0.37*
		Desire for notemaking, syllabus coverage teaching	0.37*

** p < 1%: * p < 5%

grade and upper-sixth physics enjoyment and the variables of table 9.5.1. The correlation between the two criterion variables, themselves, is insignificant at 0.20.

A-level physics attainment shows the strongest association with prior attainment at O-level. Introverted pupils tend to do best. The highest achievers find the A-level physics course less philosophical than do the other group I students.

Physics enjoyment shows no association with attainment but there is a moderate correlation with a highly prestigious course rating. The students who show the strongest enjoyment tend to be those who are information or content rather than 'physics-as-a-process' oriented, which is inferred from the 'learning-by-experiment' and 'notemaking' variables. These students are also likely to have found their teacher's style interesting at O-level.

The negative association between enjoyment of the course and an 'up-to-date' or modern perception suggests that it is the traditional values and discipline of physics which is the attraction to these pupils rather than its immediate relevance to the real, technological world. This might appear a strange interpretation, when the applied science career intention of these students is considered. However, further support for the hypothesis that school physics, at least, is a form of revealed knowledge that is not supposed to relate to the 'world-as-it-is', is given by the demonstrated dislike by the students of the 'discovery' approach to physics (Appendix 9.5.5, table A) and by a significant negative correlation (-0.36) between wanting to do well in the physics examination and learning requiring initiative. As potential applied scientists, physics at A-level is seen as a necessary qualification for career purposes (table 9.5.12) but not as an integral part of the preparation of an applied scientist.

There are several other significant associations with learning-style variables for these type I students. The notemaking, syllabus-coverage teaching method is preferred by (a) high fear-of-failure scorers (r = 0.39) and (b) by syllabus-bound students (r = 0.40). The latter are likely to have poor study-methods (r = -0.35). A preference for planned, 'method' teaching is linked to a high social implications course rating (r = 0.39) but, at the same time, to a low prestige rating (r =-0.38). The directions of these correlations confirm the major role played by the teacher-directed notemaking, syllabus-coverage approach with this type of student,who welcomes this compatible style if he or she is syllabus-bound, has poor study-methods or requires strong teacher support because of fear-of-failure motivation.

In giving weight to the correlations of table 9.5.4, and to those elsewhere including the following tables for the other student-types, care must be exercised because of the uncontrolled variation in the other variables. However, the multiple regression procedure of Section 7.11 , which was permitted by the larger cluster sizes and smaller range of variables, revealed a pattern of significant beta-weights which on most occasions confirmed that obtained from the simple correlations.

9.5.4. CLUSTER II : ENVIRONMENTALLY RESPONSIVE, PHYSICS INTELLECTUALS

Four-fifths of this group are girls. As a whole, the group show the highest all-round A-level ability, but obtain slightly lower grades in physics than do cluster I type students (a mean grade of C/D as against B/C). Type II students enter the sixth-form with similar O-level physics grades to those of type I.

Throughout the A-level physics course, type II students rate their studies significantly higher on philosophical impact than do any other of the student groups. By the end of the course, superior ratings on 'enjoyment' and 'modern course' are displayed. In the early months of the course, these students are more likely to see social implications in their lesson material, although this difference ceases to be statistically significant at the end of the two years.

The students display significantly better study methods in the sixth-form, where they are characterised by high intrinsic and low extrinsic motivation scores. Thus, there is a strongly expressed desire to study subjects for their own sake, and for inherent interest in them, rather than for extrinsic reasons such as career needs or parental pressure. In personality terms, there is a tendency for these students to be socially conforming (high LIE score - Section 7.3.3).

In the sixth-form physics classrooms, these students are the most likely ones to be in a 'matched' environment, where the teacher satisfies the students' desired approach to learning. The teaching approach adopted is also characteristic of these students; planned, logical 'method' teaching with discussion and A.V.A. media approaches. At the fifth-form stage, a similar, varied teaching provision was experienced.

<u>Inter-relationship between variables</u>

The type II cluster comprises, for the most part, an even mix of the high achieving fifth-form pupil-types A_1 and A_2. The former showed the strongest identification with a teaching-for-understanding environment in the fifth-form, and it appears that this position is maintained for these pupils in the sixth-form, where they are joined by A_2-type pupils who are 'converted' to the process approach to learning physics. Apparently recognising the nature of science, it is not surprising to find the career choices of cluster II students biased towards the pure sciences (table 9.5.3).

Table 9.5.5 shows the significant associations with the criterion variables of physics grade and course enjoyment.

TABLE 9.5.5. CRITERION CORRELATIONS FOR TYPE II STUDENTS

Variable	A-level physics grade	Variable	Course enjoyment
Physics as a problem-solving activity+	0.48*	Learning-by-experiment	0.61**
O-level study methods	-0.48*	Philosophical course	0.54*
Intrinsic motivation	0.45*	Number of O-level passes	-0.49*
Preference for planned, logical 'method' teaching	0.44*	Physics identification at O-level	0.49*

** $p < 1\%$; * $p < 5\%$

+This variable appears as a subscale of the fifth-form attitude variable physics identification (Section 5.2.5)

A-level physics attainment shows association with the three 'process' or intellectual variables of (a) physics as problem-solving, (b) study for its own sake (intrinsic motivation) and (c) a preference for effective structured communication ('method' teaching). The appearance of the O-level study methods variable could be indicative of low study methods scorers in the fifth-form (a characteristic of A_1-type pupils) achieving good A-level grades because of their sixth-form subject mastery.

Correlates with enjoyment confirm the importance of the intellectual, quality-of-learning variables. Wanting to learn-by-experiment (in the fifth-form, at least) in a subject which has a personal meaning and draws a strong loyalty from the student, is clearly associated with enjoyment. Liking for the subject in the fifth-form carries over and runs through the A-level course. Academic 'high fliers', according to the O-level pass number criterion, tend to display a lower subject enjoyment and rate the course as 'out-of-date' (r = 0.50).

Other statistically significant associations between variable scores which have educational implications are summarised below.

1. Students preferring planned, 'method' teaching are likely to rate their courses highly on 'social implications' and as being modern in outlook. (r = 0.49 and r = 0.49, respectively). Such students will have met up with an interesting teacher style at O-level (r = 0.50). In classes where the planned, 'method' approach is adopted, there is a general match between preferred and actual classroom activities (r = 0.52).
2. Students expressing a need for learning-by-experiment at O-level are likely to rate the A-level course as highly prestigious (r = 0.51), and prefer not to be taught by the notemaking, syllabus coverage method (r = -0.48).
3. Students preferring the pupil-initiative approach to sixth-form learning and teaching tend to find the subject easy (r = 0.54).
4. Students with an O-level background of a matched classroom environment with a comprehensive exposure to the varied, teaching-for-understanding

style tend to be less affected by a fear-of-failure in the A-level course (r = 0.51 and r = 0.51, respectively). High ability students with good study habits have low fear-of-failure scores (r = -0.45 and r = -0.48 , respectively).

5. 'Syllabus-free' students tend to be those who, at O-level, rated the subject image (satisfaction) of physics highly (r = 0.65) and who were well motivated towards the subject (r = 0.65).

9.5.5. CLUSTER III : ABLE BUT RELUCTANT PHYSICISTS

This is another female dominated cluster with, this time, two-thirds of its members girls. It is high scoring group on general A-level ability, being comparable with group I. Physics grade scores are just average, however, and are nearer to grade D than grade C. At fifth-form level, general O-level ability as measured by the number of O-level passes (mean 8.8) is much higher than for any other group, although this difference fails to reach a statistically significant level. The students of this group are more likely to be 'pressed' into taking A-level physics for some external reason, such as the need for a career qualification (Section 5.6). Two thirds of type III students find themselves in this category, studying a subject they would have avoided if they could. There is some further support for this finding from the above average extrinsic motivation scores showed by these students.

In the sixth-form, a whole range of course attitude, motivation and teaching-method variables fail to show any significant differences. It is only at fifth-form level that further characteristics of these students can be seen. Physics was found difficult and a 'slog', it was not enjoyed and gained little allegiance, suffering from a poor image as a discipline. It was taught in classes where there was little teaching-method 'match' and little of the varied, teaching-for-understanding style. Motivation and study methods were poor, relative to the other academic pupils who were to enter the sixth-form to study physics.

Inter-relationships between variables

Table 9.5.3 indicates that cluster III draws a substantial part of its membership from 'mis-matched' O-level stereotypes B and D_{2B}. The latter tend to find the subject particularly difficult in the fifth-form. The major career area remains pure science, but one quarter of the group choose non-scientific careers.

The significant associations for the two major criterion variables for this group appear in table 9.5.6.

TABLE 9.5.6. CRITERION CORRELATIONS FOR TYPE III STUDENTS

Variable	A-level physics grade	Variable	Course enjoyment
O-level physics grade	0.60**	Philosophical course	0.46*
Historical approach	0.59**	Easy course	0.44*
Extrinsic motivation	-0.45*		

** p < 1%: * p < 5%

The best physics grades are obtained by students who have good O-level grades; who follow an A-level course with a historical bias, and who have low extrinsic motivation scores.

Physics enjoyment is most strongly associated with course ratings on 'philosophy'and 'easiness'. There is no significant association between A-level grade and course enjoyment.

Thus,there is now evidence that able pupils, who were disenchanted with physics at O-level could benefit by being presented with an A-level treatment <u>which emphasises the historical and philosophical nature of physics</u>.

The mean scores on the A-level teaching methods variables (table 9.5.1) seem unremarkable, but significant correlations do exist between these variables and those measuring the students' characteristics.

1. Students who prefer to be taught by the planned, 'method' approach are likely to have found the subject difficult at O-level ($r = 0.46$) while rating the subject image (satisfaction) highly ($r = 0.68$). They tend to dislike pupil-initiative teaching ($r = 0.48$). These students are likely to receive planned, 'method' teaching as they desire ($r = 0.46$).
2. Students who prefer the notemaking, syllabus-coverage style of learning are likely to be syllabus-bound ($r = 0.47$) and to have poor study habits ($r = 0.50$). They tend to dislike

pupil-initiative teaching (r = 0.59). In reality, the teaching they experience has some match with their preferred method (r = 0.44).

3. Students who experience the notemaking, syllabus-coverage teaching approach tend to rate the course poorly in prestige terms (r = -0.48).

4. When the teaching style in the sixth-form is the planned, 'method' approach, this is likely to follow an O-level exposure to the similar, varied teaching-for-understanding method (r = 0.43). The whole sixth-form classroom environment is likely to match the students' needs (r = 0.46). The students experiencing planned, 'method' teaching tend to be introverted (r = 0.49).

Earlier, in Section 7.11 , when making recommendations for fifth-form teaching, it was suggested that the varied, teaching-for-understanding method could be an answer to the problem of subject difficulty. It is interesting to see that this is also the intuitive response of these type III students, who give O-level physics the highest 'slog' rating of all the five groups.

The association between syllabus-boundness and a preference for the strongly teacher controlled, notemaking/syllabus coverage style serves as a validity check on the syllabus-bound scale; both measure a narrow, restricted approach to the curriculum. There is also a negative correlation between syllabus-boundness and intrinsic motivation (r = 0.58) for type III students, which confirms the somewhat anti-intellectual nature of the 'syllabus-boundness' concept.

9.5.6. CLUSTER IV : DISILLUSIONED, O-LEVEL 'PEAK' PHYSICISTS

Just one girl is found in this group, which , in terms of general A-level ability, is the weakest of the five groups with a mean subject grade of D/E, Performance in A-level physics mirrors this low mean subject grade.

A major characteristic of type IV students is the high proportion of this group (90%) who choose to study A-level physics freely, without feeling the effects of any external constraints. Indeed, at O-level, physics presents a highly attractive image to these students as a modern and exciting subject to study ('satisfaction' score).

Apparently, physics in the sixth-form does not turn out to be exactly as was expected. Attitudes during the sixth-form course are only average, but with O-level physics grades nearer to 'B' than 'C', the poor A-level scores mean that this major group shows the largest deterioration in attainment over the two years.

These students are further typified by their preferred mode of learning. They desire the notemaking, rapid syllabus coverage style and report that, in this respect, the classroom matches their needs.

Inter-relationships between variables

There are certain similarities between type IV and type I students (table 9.5.3). Both groups have similar O-level backgrounds with the majority coming from the 'natural physicists' (cluster A_2) of the fifth-form. The career aspirations of the two groups are comparable too, although there is just a hint that type IV students are prepared to consider less academic options. Both the groups are almost exclusively male.

Differences between the two groups are relatively clear from table 9.5.1 but are put into sharper perspective when a direct comparison of groups means is made and tested for significance (table 9.5.7). In particular, type IV pupils are seen to be more extraverted and more motivated through fear-of-failure than their type I fellows. The cognitive difficulties that the type IV students encounter in studying advanced physics stand out clearly. These students are not so strongly attracted by the academic nature and quality of their studies (low intrinsic and academic motivation scores). Aware of their lack of progress and command of the subject material, and disturbed by the prospect of failure (see paragraph 5, p.533), they are forced to accept a measure of didactic, notemaking, syllabus-coverage teaching. Fear-of-failure correlates significantly ($r \doteq 0.41$) with experience of the 'notemaking' style. However, the tendency towards extraversion also demands a classroom environment in which they,the students themselves, can control to some degree their own learning. The apparent match of the classroom events with students needs in this case does little to improve student performance.

TABLE 9.5.7. SIGNIFICANT DIFFERENCES BETWEEN TYPE I AND TYPE IV STUDENTS

	Variable	Mean raw score with standard deviation in brackets: Type I (N=34)	Type IV(N=30)
	SEX	33 boys:1 girl	29 boys:1 girl
Attainment	A-level score	4.66 (1.30)	2.47 (0.82)**
	A-grade physics	5.12 (1.45)	2.34 (0.80)**
	O-grade physics	5.35 (0.60)	4.73 (0.58)**
	No. of O-level passes	8.15 (1.58)	7.53 (1.36)
Post-test attitudes	Historical	5.12 (1.45)	5.27 (0.94)
	Prestige	5.53 (1.05)	5.40 (1.40)
	Social implications	3.06 (1.43)	3.63 (1.52)
	Philosophical	3.76 (1.58)	3.37 (1.87)
	Modern	4.38 (1.37)	5.17 (1.15)*
	Enjoyment	23.97 (5.46)	23.03 (4.66)
	Easiness	13.91 (4.18)	10.97 (2.99)**
Pre-test attitudes	Historical	5.12 (1.25)	5.40 (1.07)
	Prestige	5.32 (1.12)	5.77 (1.10)
	Social implications	3.15 (1.21)	4.20 (1.10)**
	Philosophical	3.12 (1.43)	4.07 (1.26)**
	Modern	4.76 (1.54)	5.27 (1.11)
	Enjoyment	25.53 (4.75)	26.03 (3.99)
	Easiness	12.59 (3.26)	10.67 (2.38)**
Sixth-form study and motivation scores	Fear-of-failure	9.53 (2.45)	11.80 (3.20)**
	Syllabus boundness	12.47 (2.99)	13.07 (2.89)
	Study methods	20.26 (4.77)	18.23 (4.30)
	Intrinsic motivation	10.62 (3.25)	8.67 (2.62)*
	Extrinsic motivation	13.32 (2.32)	14.43 (2.66)
	Academic motivation	14.62 (2.91)	12.70 (2.97)*
Examination motivation in physics	A-level	3.94 (0.24)	3.53 (0.68)**
	O-level	3.79 (0.48)	3.60 (0.50)
Personality	Extraversion	9.74 (4.57)	12.30 (3.40)*
	Neuroticism	11.09 (4.37)	9.93 (3.16)
	Lie	3.09 (1.46)	2.80 (1.47)
A-level physics teaching methods	PLANMETH (P)	35.59 (2.90)	35.47 (2.56)
	PLANMETH (E)	26.00 (3.38)	27.60 (3.31)
	NOTESYL (P)	16.06 (2.73)	19.80 (3.78)**
	NOTESYL (E)	16.38 (1.94)	18.93 (2.27)**
	PUPINIT (P)	16.94 (2.86)	18.50 (1.96)*
	PUPINIT (E)	14.74 (3.01)	16.93 (2.42)**
	Matched to pupils needs	17.94 (4.79)	19.07 (5.56)
Choice of A-level physics	Free or pressed	28 free: 6 pressed	27 free: 6 pressed
	Mathematical and easy	1.06 (0.74)	0.70 (0.70)
O-level phys. teaching methods	VARUND (P)	25.62 (2.26)	26.57 (2.03)
	VARUND (E)	22.56 (4.29)	24.70 (2.95)*
	Matched to pupils needs	9.62 (3.38)	11.87 (3.37)*
O-level attitudes	Physics identification	77.44 (9.60)	74.17 (6.24)
	Learning-by-experiment	21.74 (3.70)	22.70 (3.49)
	Physics satisfaction	10.88 (1.09)	11.60 (0.72)**
	Physics 'slog'	2.50 (0.71)	3.47 (1.28)**
	Interesting teaching style	3.12 (1.01)	3.53 (0.78)
O-level study and motivation scores	Study methods	5.56 (2.08)	5.73 (1.74)
	Academic motivation	12.15 (1.97)	11.97 (1.52)
	Physics study methods	6.47 (2.18)	6.47 (1.72)
	Physics motivation	13.32 (1.27)	13.17 (1.15)

**p < 1%; * p < 5% (t-test)

There is evidence, here, that the teacher could make a more positive contribution to diagnosing the students' cognitive deficiencies and planning appropriately, rather than perpetuating a situation whereby worried students are superficially satisfied with a classroom provision which finally culminates in examination failure.

A discriminatory analysis procedure was run to determine which variables most effectively discriminated between type I and type IV behaviour (Appendix 9.5.3). These were found to be the attainment variables, fear-of-failure and academic motivation, and the preference for the notemaking, syllabus-coverage teaching style. Using a single function, weighted appropriately towards these major variables, 62 of the 64 students in the type I and IV categories could be correctly classified.

Although type IV students achieve only low grades in A-level physics, there is sufficient variation in these grade scores to demonstrate two significant achievement correlations (table 9.5.8). 'Commitment to physics' is a sub-scale of the fifth-form enjoyment scale (Section 5.2.5).

TABLE 9.5.8. CRITERION CORRELATIONS FOR TYPE IV STUDENTS

Variable	Correlation with A-level physics grade	Variable	Correlation with course enjoyment
Commitment to physics	0.42*	Modern course	0.45*
O-level difficulty	-0.39*	Fear-of-failure	-0.40*
		O-level classroom match	0.36*

*p < 5%

If the students in this group do get a measure of success in A-level physics, then they are likely to have found the O-level course relatively easy and to have displayed a particular commitment to physics as a career area at this earlier time. Both attainment 'predictor' variables measure fifth-form characteristics, which seems to emphasise the relatively sterile sixth-form environment for these students. Commitment to physics in the fifth-form, is apparently strong enough to have significant bearing on A-level attainment. However, there is no sign of this original drive to study physics appearing at the end of the sixth-form as a determination to do well in the A-level examination (in other words, there is no association between A-level physics grade and examination motivation). This suggests that high fifth-form 'commitment' scorers become as disenchanted as their fellows during the A-level course, and no longer rate it so important to do very well in the examination as their career plans are tentatively revised.

Students who give the course a 'modern' rating; who are not strongly motivated by the fear of failure, and who experienced a matched classroom environment in the fifth-form, show the greatest enjoyment of A-level physics.

Significant correlations between other variables permit a further insight into the characteristics of the type IV students.

1. The more introverted students tend to be anxious

(r = 0.43), to have low academic achievement motivation (r = -0.45) and to be the ones most likely to receive the notemaking, syllabus-coverage type of teaching (r = 0.41).

2. The students who prefer to be taught by the planned, 'method' style are likely to have good O-level physics grades (r = 0.66), but are likely to have been 'mismatched' in their classrooms in both the fifth- and sixth-forms (r = -0.45 and -0.42, respectively). These students would have been taught by a teacher with a relatively uninteresting style in the fifth-form (r = -0.44). Students who actually receive the planned, 'method' approach in the sixth-form are to be found most often in a matched classroom environment (r = 0.41). Such students tend to find the subject easy (r = 0.45) but are likely to be syllabus-bound (r = 0.50).

3. Students preferring pupil-initiative teaching tend to find the subject difficult (r = 0.49) and to have high extrinsic motivation scores (r = 0.45).

4. The more able, all-round A-level students are likely to find the course philosophical (r = 0.37).

5. Fear-of-failure motivation is associated with poor study habits (r = -0.50) with subject

difficulty at both O- and A-level (r = 0.42 and 0.39 respectively), and of course with lack of subject enjoyment (table 9.5.8).

The pattern of correlations above supports the inferences drawn from table 9.5.7. The didactic, notemaking style of teaching might be 'popular', but there appears to be no rationale underlying this attraction (in terms of significant correlations)., apart from an overall reaction of the students to the unenviable position that they find themselves in. Indeed, it is the planned, 'method' approach to learning that emerges as desirable for these students, being associated with easiness and a matched environment. As it is the students who find the course relatively easy who get the better grades, the classroom behaviours that satisfy these students (planned, 'method' teaching as defined in Section 5.11.4) should be considered by teachers of type IV students in an attempt to create an optimum atmosphere for all students in the 'disillusioned' category.

Even so, there is some evidence that syllabus-boundness is a positive characteristic for these students. This might be because these relatively less able students realise that, although an understanding of physics as implicit in the planned 'method' approach is desirable, their limited intellectual capabilities prevent them from moving far from a rather tightly prescribed body and mode of learning. Type IV students exhibit the characteristics of 'surface processors' (Section 9.3.5).

9.5.7. CLUSTER V : POOR ACHIEVING PHYSICS SUFFERERS

This is an all-male cluster. Like cluster IV, it is characterised by poor A-level achievement. The mean subject A-level grade is nearer to 'D' than 'E' but performance in physics is below this average at grade E.

Students of type V are distinguished by their consistent, relative dislike of physics. At O-level, this relative dislike appears as low identification (enjoyment/commitment) scores. After a month or so of the A-level course, poor enjoyment is measured again. At the end of the course, the enjoyment scores are even lower.

On entering the sixth-form, most of the type V students have the lowest O-level pass grade C. Sixth-form study methods are relatively poor, as are academic motivation and intrinsic subject motivation. The physics classrooms show a poor match with the expressed needs for these students: in particular, there is a poor provision of planned, logical 'method' teaching.

<u>Inter-relationships between variables</u>

In the fifth-form, type V students were, for the most part, to be found in the two major physics choosing groups (table 9.5.3), although very much towards the lower end of the attitude and ability spectrum. Indeed, two students entered the sixth-form without reaching O-level physics pass standard. Career areas for type V students are more diverse, reflecting a weaker commitment to science than that shown by the other groups.

Simple correlations, where significant, for the two criterion variables of A-level physics attainment and course attitudes appear in table 9.5.5.

As most students fail the examination, the attainment correlations are perhaps more comfortably examined if their directions are reversed and associations with the poorest grades considered. Students who do badly prefer to be taught by the planned, logical 'method' style, but are likely to be in 'mis-matched' classrooms where the teaching does not meet their needs. (Also see Appendix 9.5.4). Those who do better tend to have the higher extrinsic motivation, that is, are subject to the greatest external pressures.

The students who enjoy the course least are those at O-level, who were most strongly motivated towards physics and other academic studies. The lack of any significant sixth-form motivation correlate here suggests that there is no simple carry-over of motivation from the fifth-form.

TABLE 9.5.9. CRITERION CORRELATIONS FOR TYPE V STUDENTS

Variable	Correlation with A-level physics grade	Variable	Correlation with course enjoyment
Preference for planned, 'method' teaching	-0.65**	Learning-by-experiment	0.67**
A-level classroom match	0.64**	Prestigious course	0.57**
Extrinsic motivation	0.49*	O-level academic motivation	-0.55*
		Syllabus-boundness	0.49*
		O-level physics motivation	-0.49*

** p < 1%: * p < 5%

Students who enjoy the course most also rate it of relatively high prestige, and although 'syllabus-bound' in the sixth-form these students preferred to 'learn-by-experiment' at O-level (learning-by-experiment correlates at 0.59 with syllabus-boundness).

Other significant between-variable correlations show that type V students,

1. who prefer the notemaking, syllabus-coverage teaching approach are likely to have poor study habits (r = 0.46); are likely to rate success in the A-level physics examination highly (r = 0.46), and are likely to actually experience their preferred teaching method in class (r = 0.54);
2. who are anxious in disposition are those most likely to have the best academic achievement motivation (r = 0.56) and to have been taught physics by a teacher with an interesting style in the fifth-form (r = 0.53);
3. who rate success in the A-level physics examination highly tend to be following an out-of-date course (r = 0.52);
4. who find the course relatively easy are most likely to rate it 'modern' (r = 0.48);
5. who have the highest academic achievement tend to be following an out-of-date course (r = -0.53) and to have had a poor image of physics as a subject at O-level (r = -0.51), and

6. who gain the greatest number of O-level passes are likely to have the highest fifth-form academic motivation scores (r = 0.54) and the highest sixth-form extrinsic motivation scores (r = 0.53).

These correlations contribute to an overall pattern of type V behaviour where a relatively unpopular O-level subject is continued through the sixth-form (mainly for career reasons) in classrooms where the course material appears outmoded and the teaching approach is severely mismatched. To alleviate the latter, it is particularly important to integrate practical work more meaningfully into the theoretical course (see Section 9.5.8). The cognitive level of the teaching for these students (table 9.5.11) is too high : the remedy requested by the least successful students is for planned, logical, 'method' teaching. At the moment, the few students in group V who still value a good physics grade highly, apparently try to come to terms with their condition, and look to the notemaking, syllabus-coverage approach to get them the success their extrinsic motivation demands (Appendix 9.5.4).

9.5.8. PREFERRED AND EXPERIENCED TEACHING METHODS

The statements and scales describing the preferred teaching and learning styles in the upper-sixth physics classes have been analysed for the whole student population in Section 9.4. Here, in table 9.5.10, cluster differences are explored.

TABLE 9.5.10. CLUSTER DIFFERENCES IN TEACHING METHOD RESPONSES

Statement	Method preferred (P) or experienced (E)	Mean group score I	II	III	IV	V
1. Teaching is by lectures with experimental demonstrations	P E	2.56 1.85**	2.65 2.15*	2.48 2.19	2.47 1.77**	2.42 1.95
2. Learning is by finding out by oneself after each new topic has been introduced by the teacher	P E	1.71 1.32*	2.30 1.85*	2.10 1.57*	2.23 1.63**	1.90 1.63
3. The class works through a textbooks	P E	1.71 1.65	1.95 2.05	1.67 1.71	1.83 2.07	1.68 2.05
4. The teacher guides you in your learning, acting as a source of information, asking questions and using experimental demonstrations to help	P E	2.82 2.35**	2.70 2.75	2.71 2.29*	2.83 2.47**	2.84 2.42*
5. Part of the course is devoted to an individual student project	P E	2.14 1.00**	2.00 1.00**	2.14 1.00**	2.07 1.07**	1.90 1.00**
6. Individual homework and practical accounts are assessed and discussed by the teacher	P E	2.65 2.21*	2.85 2.70	2.95 2.52*	2.77 2.37**	2.63 2.16*
7. The teacher uses words rather than mathematics in explanations whenever possible	P E	2.44 2.12*	2.50 2.35	2.48 2.24	2.50 2.10*	2.42 1.84*
8. The teaching order appears logical	P E	2.91 2.15**	2.95 2.80	2.91 2.38*	2.80 2.33**	2.63 1.90**
9. The teacher anticipates the students' problems and sees the subject from their point of view	P E	2.94 1.97**	2.90 2.45*	2.62 1.86**	2.87 2.23**	2.63 1.63**
10. The teaching style encourages the interest of the student	P E	2.91 1.74**	2.90 2.35**	2.86 1.91**	2.80 2.03**	2.58 1.32**

TABLE 9.5.10. CLUSTER DIFFERENCES IN TEACHING METHOD RESPONSES(cont'd)

Statement	Method preferred (P) or experienced (E)	Mean group score				
		I	II	III	IV	V
11. To help you understand, films, filmstrips and filmloops, are used as well as experimental demonstrations	P E	2.56 1.65**	2.30 1.30**	2.62 1.71**	2.47 1.50**	2.63 1.42**
12. Students' practical work is related to recent teaching lessons	P E	2.91 2.38**	3.00 2.75	2.95 2.67*	2.90 2.50**	3.00 2.37**
13. The lessons are planned to make experimental and theory work run smoothly	P E	2.94 2.03**	2.95 2.50*	2.91 2.43**	2.80 2.30**	2.63 2.05*
14. Visits to outside events are sometimes arranged to broaden your knowledge of physics	P E	2.53 1.24**	2.65 1.70**	2.62 1.52**	2.67 1.93**	2.32 1.37**
15. The teacher uses lesson material from outside the examination syllabus when it is felt necessary	P E	2.24 1.88*	2.55 2.10*	2.19 2.19	2.47 2.10*	2.37 2.16
16. You are encouraged to work as an individual rather than as part of a large group of four or more	P E	2.65 2.50	2.75 2.65	2.76 2.57	2.47 2.30	2.42 2.53
17. All students make their own notes and records of work covered in lessons	P E	1.97 1.94	2.15 1.85	2.10 1.91	2.60 2.23*	2.32 2.05
18. Some students make notes and circulate them to others	P E	1.03 1.09	1.15 1.05	1.10 1.14	1.27 1.30	1.63 1.26
19. Notes are made from dictation by the teacher	P E	1.68 2.03*	2.20 2.15	2.33 1.91*	2.37 2.13	1.84 2.26
20. Notes are made by copying from the board or overhead projector	P E	2.09 2.27	2.20 2.15	2.38 2.33	2.47 2.27	2.27 2.53
21. Duplicated lesson notes are issued on a short loan	P E	1.53 1.06**	1.90 1.35**	1.48 1.19	1.73 1.33*	1.84 1.16**

TABLE 9.5.10. CLUSTER DIFFERENCES IN TEACHING METHOD RESPONSES (cont'd)

Statement	Method preferred (P) or experienced (E)	Mean group score I	II	III	IV	V
22. Notes are made by a number of different methods	P	2.21	2.50	2.38	2.80	2.47
	E	1.79*	2.30	2.29	2.57	2.16
23. The teaching relates each new idea to a previously understood one	P	2.88	2.90	2.76	2.83	2.84
	E	2.12**	2.45**	1.86**	2.27**	1.95**
24. The teaching seems to be most suitable for the most able pupils	P	1.85	1.60	1.47	1.60	1.26
	E	1.79	1.70	2.10**	2.10**	2.47**
25. Students' practical work occurs in groups of four or more in the normal lessons	P	1.21	1.35	1.19	1.67	1.37
	E	1.09	1.15	1.14	1.57	1.26
26. Several teachers take the class, each one teaching a different topic	P	1.67	1.95	1.38	1.90	2.00
	E	1.47	1.30**	1.43	2.00*	1.58
27. Homework relevant to teaching and practical lessons is set regularly	P	2.82	2.90	2.91	3.00	2.90
	E	2.24**	2.75	2.29**	2.73*	2.32*
28. The special type of individual work for the A-level practical exam is introduced into practical lessons towards the end of the course	P	2.21	2.40	2.43	2.63	2.42
	E	2.00	2.05	2.52	2.23*	1.63*
29. The teacher encourages discussion and speculation amongst the students	P	2.82	3.00	2.86	2.90	2.47
	E	2.18**	2.55*	2.24**	2.30**	1.79*
30. The whole syllabus will not be completely covered, but the topics taught will have been thoroughly treated	P	2.00	2.25	2.10	1.87	1.68
	e	2.00	2.20	1.86	1.63	1.90
31. Technical terms are used where appropriate, but otherwise the language is every day English	P	2.77	2.95	2.81	2.80	2.68
	E	2.74	2.85	2.81	2.73	2.32

TABLE 9.5.10. CLUSTER DIFFERENCES IN TEACHING METHOD RESPONSES (cont'd)

Statement	Method preferred (P) or experienced (E)	Mean group score				
		I	II	III	IV	V
32. Practical work is designed to help the student understand the knowledge from theory lessons	P	2.88	2.95	3.00	2.97	2.63
	E	2.47**	2.90	2.81	2.80	2.11*
33. Each topic in the course is studied in depth	P	2.56	2.55	2.29	2.53	2.58
	E	2.09**	2.15*	2.10	2.00**	2.42
34. The teacher covers the syllabus quickly to leave as much time as possible for revision	P	1.59	1.45	1.86	1.97	1.90
	E	1.74	1.75	1.86	1.90	1.68
35. Individual or small group practical work takes place each week in a separate practical lesson	P	2.74	2.85	2.76	2.70	2.79
	E	2.56	2.60	2.62	2.23**	2.58
36. Students are helped and encouraged to revise for the A-level exam in a planned way	P	2.79	2.80	2.48	2.97	2.58
	E	2.29**	2.25*	2.24	2.33*	1.79 *
37. Each lesson has an introduction, which tells you what the lesson is about, and a conclusion which summarises the lesson's content	P	2.35	2.50	2.19	2.27	2.37
	E	1.27**	1.50**	1.19**	1.20**	1.11**
38. Regular practice to develop a suitable style in answering exam questions occurs in the second year of the course	P	2.74	2.85	3.00	3.00	3.00
	E	2.12**	2.40	2.48*	2.63**	2.05**
39. All exam revision is done from the students' own notes	P	1.41	1.55	1.57	1.77	1.53
	E	1.82**	1.70	1.81	1.93	2.05*
40. The whole syllabus will be covered but not all the topics will have been thoroughly treated	P	1.65	1.85	1.62	2.03	1.79
	E	1.82	2.05	2.10*	2.27	1.90

Single and double asterisks indicate significant differences at the 5% and 1% levels, respectively, between preference and experienced teaching scores.

Differences in the response distributions to the preference and received teaching versions of each statement were tested for each pupil group by means of the Wilcoxon matched-pairs test (Siegel, 1956). For any one statement, significant differences, when they occurred, did not necessarily appear across all groups. Outstanding group differences are:

statement 4, 'guided learning', the match of preference and received teaching occurs with type II students only;
statement 6, 'homework feedback', only type II students show a 'match';
statement 8, 'logical order', only type II students show a'match';
statement 12,'related practical work', only type II students show a 'match';
statement 15,'outside syllabus', type III students tend to expect less of this type of teaching and report a 'match';
statement 17,'students make own notes', type IV students think this a good method but report a 'mis-match';
statement 19,'teacher dictation',type I students think this a poor method and report a significant mis-match: type III students think this is a good method but also experience a mis-match;
statement 22,'varied notemaking', type I students are less likely to experience this approach;
statement 24,'teaching for the most able', types III, IV and V see their lessons pitched at the higher ability levels;
statement 27,'regular homework'; only type II students are satisfied with this provision;
statement 28,'exam practical preparation'; students of type IV and V report an under-provision;
statement 32,'practical to help theory', this approach is less likely to be experienced by type I and type V students;
statement 33,'depth of treatment', students of type I, II and IV are less satisfied with the depth of their studies;
statement 35,'separate practical lessons', type IV students report an under-provision here;
statement 36,'planned revision', only type III students show satisfaction with this provision.

In some instances, the different student groups show differences in preferences. For example, the discovery approach, as defined by statement 2, is rated a poor method by the students of groups I and V.While this is not unexpected for type V students with their poor attitudes towards academic subjects, the response to this particular item helps to characterise type I students. They have been described earlier as 'mathematical physicists' now, in addition, an identification with a 'safe' rather than adventurous approach to the subject is revealed. Comparing the responses of type I and type II students to preference statement 2 (Appendix 9.5.5 , table A) shows that the latter are more likely to welcome an inquiry approach to the subject.

TABLE 9.5.11. CHARACTERISTIC PREFERENCES

Preference statement (abbreviated)	Student type I	II	III	IV	V
17. Students make own notes				+	
19. Teacher dictation	-				
22. Varied notemaking				+	
24. Teaching for the most able					-
36. Planned revision				+	

+ indicates a significantly greater preference
- indicates a significantly greater dislike
(Appendix 9.5.5.)

Other characteristic preferences as summarised in table 9.5.11. Attention has already been drawn in Section 9.5.7 to the significance of type V students' dislike of 'teaching for the most able'.

9.5.9. CHOOSING A-LEVEL PHYSICS

Significant overall differences

Reasons for choosing A-level physics had been checked in the lower sixth-form (Section 8.3). The reasons are analysed by cluster type in table 9.5.12 , using the chi-squared statistic. The sizes of the clusters permitted relatively few significant characteristic differences to emerge. Nevertheless, it is clear that, in choosing A-level physics,

a) finding the O-level course is easy is a factor for type I students;

b) an interesting O-level course is a major reason for type II students, and

c) type III students are more likely to be influenced by O-level physics attainment.

Differences between clusters I and II

Significant differences at the 5% level are shown in the responses of students of types I and II to statements 3 and 5.

Type I students are more likely to give 'university and/or career requirements' as one of the check-list reasons and also as the most important reason. Type II students are most likely to give 'O-level course was interesting' as the most important reason.

Some further overall trends

Other between cluster comparisons are largely insignificant in statistical terms but, when considered with other evidence in Section 9.5 , confirm the revealed

TABLE 9.5.12. REASONS FOR CHOOSING A-LEVEL PHYSICS - CLUSTER DIFFERENCES

Statement	Percentage of students in cluster									
	giving statement as a reason					giving statement as the most important reason				
	I N=34	II N=20	III N=21	IV N=30	V N=19	I N=34	II N=20	III N=21	IV N=30	V N=19
1. You had a high O-level physics grade	50	55	38	43	21	6		19**	3	
2. You had a better grade in physics than in most other subjects	9	30	14	27	11			5		
3. University and/or career requirements	100	80	67*	90	90	82	50	52	73	84
4. It was not to be a main subject but was decided by school/college timetable		10	10		11		5			
5. The O-level course was interesting	59	70	43	67	47	3	30**	5	7	5
6. You had heard that the A-level course was interesting	18	25		33	21		5		3	5
7. The O-level course was easy	29**	5	5	7	11					
8. Physics allows you to use your mathematical ability	47	50	43	43	32	3	5	5	3	
9. You were attracted by the amount of student experimental work in physics	27	20	29	23	21			5	7	
10. Not so much hard work is expected in A-level physics as in other subjects			10**							
11. You had heard that it is easier to pass in A-level physics than in most other subjects			5							
12. You were attracted by the A-level teaching methods in physics	3	15	14	3	11			5		
13. You were attracted by the type of exams in A-level physics	3		5		5					
14. You had heard that it is more difficult to pass in A-level physics than in most other subjects but you were confident that you could manage	24	20	10	17	16					
15. More hard work is expected than in some other subjects but you thought that you could manage	21	40	33	40	23			5		
16. To improve your understanding of science in the world today	50	50	33	37	47	3	5		3	5

Single and double asterisks indicate significant differences at the 5% and 1% levels, respectively, between the responses of the cluster so marked and the pooled responses of the remaining clusters characteristics of the five clusters.

Apart from the statistical differences between type I and type II students above, it appears that the former are more single minded about studying physics (attainment in other subjects is relatively unimportant - statement 2). Type II students weigh up the implications of their choice carefully, considering other subjects, the likely attraction of the physics teaching, and possible cognitive difficulties (statements, 2, 12, and 15).

The attainment oriented students of type III seem to rate subject interest of less importance than do the other types when making the A-level choice (reasons 5 and 6).

Type IV students are clearly influenced by subject interest when choosing A-level physics. They have found the O-level courses interesting and anticipate (wrongly, as it turns out) that the A-level course will continue to be satisfying in this respect. There is a hint of possible trouble ahead, though, the 'hard work' statement 15 is firmly rated but the 'easy O-level' reason, 7, draws little support. The attraction of physics does not, apparently, extend to science (and its implications) as a whole with only a moderate rating for reason 16.

It is difficult to classify the type V students on the data of table 9.5.5 alone. Of course, with their modest O-level grades in physics, attainment is unlikely to be a reason for choosing the A-level subject (reason 1 draws the lowest response of all the five cluster groups). The career requirements reason is thus particularly strong, but, with relatively poor initial sixth-form attitudes, it is easy to see why type V students would find sixth-form work difficult.

9.5.10 DISCRIMINATING BETWEEN THE FIVE STUDENT GROUPS

The S.P.S.S. 'Discriminant' procedure (Section 2.9) was used to test a selection of the variables of table 9.5.1 to see whether they would discriminate between the five student stereotype groups. The initial set of variables chosen comprised those which measured attitudes and attainment at the end of the sixth-form course and those major attainment, attitude and personality variables from the fifth-form which were not superseded by the sixth-form tests.

Some 24 discriminatory variables were identified, which were then combined by the statistical procedure into four discriminant functions. These functions act in mutually orthogonal directions and produce maximum separation of the five student groups. The relative contribution of each variable to a discriminant function is expressed by a standardised coefficient. The full matrix of coefficients appears in Appendix 9.5.6. Table 9.5.13 shows the coefficients for the main function, which accounts for some 54% of the variance in the 24 discriminating variables.

TABLE 9.5.13. STANDARDISED DISCRIMINATION FUNCTION COEFFICIENTS

	Variable	Coefficient
Attainment	A-level score	-135
	A-Grade Physics	-337
	O-Grade Physics	-284
	Number of O-level passes	-150
Post-test attitudes	Historical	-005
	Prestige	-133
	Philosophical	-274
	Modern	-050
	Enjoyment	-186
	Easiness	-114
Sixth-form study and motivation	Fear-of-failure	008
	Study methods	-298
	Intrinsic motivation	-311
	Extrinsic motivation	216
	Academic motivation	-151
	A-level physics exam motivation	-447
Personality	Neuroticism	-234
	Lie	-131
A-level teaching methods	PLANMETH (P)	-126
	PLANMETH (E)	032
	NOTESYL (E)	251
	PUPINIT (P)	255
	PUPINIT (E)	-020
O-level attitudes	Physics identification	-120

Decimal points are omitted

The main function(reversing the sign of the coefficients) is a measure of academic physics success with subject motivation, achievement and study methods contributions. Type II students score most highly, with the opposite pole of the function being occupied by the students of cluster V (table 9.5.14). The other three functions are multi-dimensional and complex. With these functions, quite different groups can obtain similar scores because of the appearance of favourable, characteristic sets of variables. In all 57% of students can be successfully classified by the main functions. As table 9.5.15 shows, type I students are the most difficult to classify.

TABLE 9.5.14. CLUSTER SCORES ON THE MAIN DISCRIMINATION FUNCTION

Cluster or group	Group mean score on function (signs reversed)
I	1.67
II	2.15
III	-0.08
IV	-1.33
V	-3.07

TABLE 9.5.15. RE-CLASSIFYING CLUSTER MEMBERS USING THE MAIN DISCRIMINANT FUNCTION

Actual group	N	Predicted group membership				
		I	II	III	IV	V
I	34	13	14	7	0	0
II	20	5	13	2	0	0
III	21	7	0	7	7	0
IV	30	1	0	3	21	5
V	19	0	0	0	2	17

Even when all four discriminant functions are used to classify the students, only a 90% success rate is possible.

9.5.11. DISCRIMINATING BETWEEN PAIRS OF CLUSTERS

As it has proved rather difficult to set up common discriminatory functions to separate all five clusters, the approach used in Section 9.5.6 to distinguish between type I and IV characteristics was adopted to investigate the other possible combinations. Appendix 9.5.7 gives the discriminant function coefficients and scatterplots

TABLE 9.5.16. CLUSTER PAIRS : MAJOR DISCRIMINATING VARIABLES

Cluster pairs	Major discriminating variables	Function coefficient	Classi-fication	Comments
I and II	Easiness Fear-of-failure Study-methods PLANMETH(E)	0.56 -0.42 -0.42 -0.40	83%	Type II students find physics more difficult, have a high fear-of-failure, high study-methods scores, and get the planned, logical 'method' type of teaching.
I and III	O-Grade physics Philosophical NOTESYL (P) PUPINIT (P) Physics identification	0.61 0.42 -0.47 -0.47 0.97	98%	Type I students have the better O-level grades and attitudes; find the A-level course more philosophical and less likely to want the note-making or pupil-initiative styles of teaching.
II and III	Modern Study-methods Intrinsic motivation Extrinsic motivation Lie Physics identification	0.57 0.68 0.84 -0.51 0.66 0.62	100%	Type II students show the better intrinsic motivation and study-methods. They are more likely to rate the course 'modern'; to be socially conforming and to have enjoyed the O-level course. Type III students have the greater extrinsic motivation.
IV and V	A-level score A-grade physics O-Grade physics Enjoyment Syllabus boundness	1.24 -0.69 -0.99 -0.81 0.60	100%	Achievement and subject enjoyment distinguish between clusters IV and V. The latter show the better overall attainment but the former do (slightly) better in physics. Type IV students enjoy the course more and are less syllabus-bound

for all the possible inter-cluster pair comparisons. Table 9.5.16 reports on discrimination between the high achieving cluster pairs, I, II and III and between the low achieving cluster pairs IV and V.

Considering all possible cluster-pair comparisons, in all but three instances complete reclassification of student members was possible on the basis of a single discriminatory function, the nature of which varied, of course, from pair to pair.

While the cluster means of table 9.5.1 can, and have, been used to distinguish between the five student groups, table 9.5.16 separates the important characteristics of two students of different types in the most economical predictive way. For instance, if two students X and Y are both high achievers at A-level in general, and in physics in particular, they are likely to be of either type I or type II. The student who finds physics easier, has the lower fear-of-failure motivation, has the poorer study-methods and receives less of the planned, logical 'method' teaching, will almost certainly be of type I. The weighting to be given to these major discriminatory variables is expressed by the function coefficients.

9.5.12. SOME INTERVIEW FINDINGS

Previous reference to the interviews with upper sixth-form students has been made in Section 5.11.3. The interview schedule had been used in a preliminary pilot study with six students in a school otherwise not associated with the longitudinal attitude survey. After modification (Appendix 5.11.3), visits were made to five classes in three schools to interview, in all, 24 students.

As well as acting as a validity check on questionnaire responses, the interviews permitted the students to expand upon their likes and dislikes. In this way, it was hoped to build up a valid picture to help interpret the statistical findings from the sixth-form questionnaires.

One of the students had not been present for all the five questionnaire units. The remaining twenty three students were distributed amongst the five stereotype groups as table 9.5.17 shows.

TABLE 9.5.17. THE INTERVIEW SAMPLE DISTRIBUTION

	N	
Stereotype group	Interview sample	All students
I	6	34
II	4	20
III	3	21
IV	8	30
V	2	19

χ^2 = 1.25 with 4 degrees of freedom, not significant

There is no significant difference (χ^2-test) between the interview sample distribution and that of the survey as a whole.

Questions 1 and 2 were introductory to confirm question data and asked for subjects being studied and intending career areas.

Question 3. Examination motivation

The correlation between the interview and questionnaire responses was 0.68 ($p < 1\%$). Identical ratings were obtained from twenty students.

Question 4. Reasons for choosing physics

The major reasons given were subject interest and career needs as might be expected (Section 8.3.). Those giving A-level interest as a reason tended to express disappointment that the course had not turned out to be as interesting as they had expected. These students were exclusively of types IV and V.

Question 5. Most attractive aspect of the course

The experimental nature of the course drew the strongest support mostly from types I and II. Most students of types IV and V were unable to point to any attractive area.

Question 6. Least attractive aspect of the course

One third of the students of all types felt that the course was too difficult. The lack of experimental work (one class stopped practical work at the end of the lower-sixth) and the mathematical approach to many topics were also often mentioned by all except type I students.

Question 7. Syllabus-freedom

Responses to the two parts of this question and the first part of question 12 allowed a rough index of syllabus-freedom (0, 1 or 2) to be correlated with the S.S.R.C. scale score of Section 5.10. A correlation of 0.50 was obtained, which is significantly different from zero at the 5% level, for the two estimates of syllabus-freedom. This association can be taken as a validity measure for the S.S.R.C. scale despite the coarseness of the interview criterion measure.

Question 8. Easiest course topics

The three most often named topic areas were mechanics, heat and modern physics. Mechanics was felt to be easy because of its strong dependence upon mathematics. Heat was believed to possess no deep conceptual theory that had to be mastered as a pre-requisite so straightforward comprehension learning could be used. No one major reason for finding modern physics easy was given but its descriptive rather than quantitative nature was often mentioned.

Question 9. Difficult course topics

There was less agreement on the most difficult topic areas. Four students mentioned kinetic theory of gases with its heavy emphasis on abstract, theoretical formulae. Three students also criticised electromagnetism and electrodynamics for a similar reason.

Question 10. Number of class teachers

This question allowed one of the classroom environment items to be checked (Section 5.11.3.).The responses showed the essentially conservative nature of the students in their tendency to agree with current classroom practice. All five students in the class taught by just one teacher thought that this approach was best, mainly because of the unified presentation of subject material which can be given. The remaining students were in classes taught by two or three teachers. All but three of these students felt the multi-teacher approach superior. Reasons given included the variety of style in presenting the lesson material with more than one viewpoint; an easier arrangement for the teachers because they could concentrate on certain syllabus areas, and a smaller chance of the student finding himself in a completely incompatible environment. While favouring the multi-teacher approach, three students pointed out that if they could be sure of teaching of sufficient quality, the stability of the single teacher classroom would be ideal. The latter reason was given by the remaining three students who, although in multi-teacher classrooms, found the different styles unsettling and opted for the single teacher approach.

All but one of the students of types IV and V favoured a two-teacher organisation.

Question 11. The mathematical approach

This was another question to act as a validity check on a questionnaire item (Section 5.11.3). On a three point scale with verbal and mathematical approaches as the opposite poles, students' preferences were directed more strongly towards the qualitative, verbal approach. Only three of the students would welcome a mathematically oriented course.

When asked what approach should be used for the class as a whole regardless of personal preferences, there was a noticeable shift towards the mathematical pole on the scale. Several students said that, by tradition and teaching, phyics had to be mathematical, and so their personal preferences for a more verbal learning method had to give way to, what they felt, were the needs of the majority of the students (but in reality this was only three of twenty four students in the sample).

Question 12. Other learning sources

The first part of this question allowed a point to be scored on the three-point validity check scale for syllabus-boundness/freedom (Question 7). Nineteen of the students were prepared to consider ideas from outside the syllabus. Fifteen students expressed an active interest in physics outside the classroom with most of the extra information and comment coming from television programmes and books. Seven of the nine students not actively interested in physics were to be found in groups IV and V.

Questions 13 and 14. Lesson communication

The most important verbal exchanges, and rated as such by fifteen students, are those where questions are asked of the teacher. Questioning initiated by the teacher, although important, is not as highly rated as are discussion sessions.

All except two students made a record of lesson activities mainly by acquiring dictated notes from their teacher or from textbooks. The two remaining students simply relied upon the printed word within the text book. It was felt that notes were made for two main reasons:

(a) to help the students understand the lesson material, and (b) for examination revision. The most preferred notemaking method (one-third of the students) is using a text-book to draw up individual summary notes. The issue of duplicated lesson notes was rated a good idea by fourteen of the students, especially if the notes were to be worked through in class.

Question 15. Time allocation and practical work

The time allocation for physics varied from 4 hours 40 minutes to 6 hours per week. The average student was spending one quarter of this time on practical work. However, seven students were doing no practical work at all in the upper sixth-form.

The main aim of practical work, given by almost all the students, is to help in the understanding of theory work. Ten of the students felt that more practical work was desirable. This number included those not actually doing practical work, so is not such a strong indicator as it might otherwise be. Most students were satisfied with the amount of time allocated to practical work.

The physics course as a whole was felt to be allocated sufficient time: only four students would have welcomed a greater time allowance.

Question 16. Revision for the examination

Eleven students felt that teachers should help the students in revising for the examination: eight were against any teacher assistance. There was no relation between preference and student stereotype. Positive help was expected to be given by:

a) drawing up a revision programme

b) revising key topics in class

c) working through examination questions

d) giving individual tuition where difficulties arise, and

e) explaining the techniques required in tackling the various examination papers.

9.5.13. STUDENTS' FREE RESPONSES

Four of the five questionnaire units included a 'free response' section, where students were invited to expand upon their earlier responses to the scale items. In research terms, the unstructured responses often added little to the data already collected. For instance, fifth-form pupils would occasionally indicate that 'more experiments are needed', while the check-lists they had previously completed showed exactly that. However, from time to time, a pupil would write at some length, making some very pertinent points. An example of such a contribution appears in Appendix 9.5.8 , where a girl from the only 'Nuffield' O-level class laments the lack of applications of knowledge in physics. It is not surprising to find this girl classified as a physics-intellectual of type II when she passes through the sixth-form.

All free responses were analysed by sixth-form cluster type. Students of types I and II were most likely to express their feelings. The responses from the other student-types were confirmatory rather than revealing.

Over the duration of the survey, type I students seem more likely to have experienced poor teacher-pupil relationships. This could have happened at either fifth-form or sixth-form level. Earlier, in Section 9.5.3 , attention has been drawn to the relative environment-independence of these students. It appears that some type I students are able to succeed despite quite strong attitudinal and learning environment mis-matches with their teacher or teachers.

The 'intellectual physicists' of type II are mostly girls. As great a proportion as one in three of girls expressed the view that they were taking a traditionally male subject, sometimes against the wishes of teachers and parents, but that they were determined to succeed, even if they did find the subject difficult from time to time. This is a further confirmation of the strong task achievement motivation that girls studying advanced science outside their accustomed social role are likely to display (Saraga, 1975, and Section 2.4).

Responses given by the able but reluctant physicists of type III were too thinly scattered to conclude other than the subject was being studied for career purposes and was not particularly easy. Both these deductions had appeared independently elsewhere (Section 9.5.5).

Subject difficulty was the factor mentioned by cluster IV students. Shorter lessons were also suggested to lessen the cognitive load of the demanding theory periods.

The 'physics sufferers' of cluster V, like some of the more able type I students, report that they have encountered a mis-matched classroom in some form or other. Teachers are felt to be (a) unsympathetic to the needs of young adults, (b) teaching physics with too high a mathematical content, (c) providing insufficient experimental work, and being too concerned with academic theory and ignoring the uses of physics. (Table 9.5.11 shows that type V students show a significant dislike for 'high ability' teaching).

9.5.14. CONCLUDING REMARKS : TEACHING FIVE TYPES OF STUDENT

In all, the 124 sixth-form physicists who provided a full set of survey data were spread over 21 classes. Class sizes ranged from one to thirteen (although actual numbers were slightly greater than this, as some students had either been absent for one of the five questionnaires or had joined the class after the project had started). Only one class comprised members from each of the five student stereotypes (table 9.5.18), but a further five classes contained four stereotypes. From this, it is clear that typical A-level physics classes contain several, if not all, the identified stereotypes. Teachers are therefore faced with the problem of preparing and presenting learning opportunities that have to satisfy a range of student characteristics.

In solving this problem, it appears that some of the student groups will be more susceptible to manipulation of the environment than others. Type I students are achievement oriented, with a bias towards the traditional, disciplined, mastery of subject material approach. These students seem otherwise impervious to the method of learning and the nature of the subject. On the other hand, type II students are much more process-oriented: attainment and enjoyment outcomes have been shown to be associated with learning-by-experiment, a preference for planned, logical 'method' teaching and a philosophical approach. Also, the predominantly 'pressed' students of type III tend to be more successful if following courses which emphasise the historical and philosophical side of the

TABLE 9.5.18 THE DISTRIBUTION OF THE STUDENT STEREOTYPES AMONGST THE CLASSES

A-level class	Student stereotype				
	I	II	III	IV	V
1		1		4	2
2	1			3	
3	1	3	1		
4		2	2		
5	5		1		2
6	6	2	2	1	
7	1		1	1	
8	1	1		1	
9	1	2			1
10		1	1	2	
11	2		2	5	4
12	1				
13	4	1	3	1	2
14	2			3	
15	1			1	1
16	1	1		5	3
17	1	2			
18	3		2	2	1
19	3		2	1	3
20		3	2		
21		1	2		
ALL	34	20	21	30	19

χ^2 = 109.5 with 80 degrees of freedom ($p<5\%$), which indicates a significant variation in stereotype pattern over the classes subject. Type IV students experience considerable cognitive problems in sixth-form physics after starting out with high hopes for success. These students are strongly influenced by a fear-of-(impending) failure and are apparently driven into the 'refuge' of a preference for didactic, 'notemaking' learning: those who find the subject less difficult tend to actually receive planned, 'method' teaching. The fifth student group experience particularly mis-matched classroom learning, and again there is a wish for the 'method' approach to teaching.

The evidence is that, in so far as an optimum style of sixth-form physics teaching is possible, planned, logical 'method' teaching - as defined by the scale items below (Section 5.11.4) should be used widely.

37. Each lesson has an introduction, which tells you what the lesson is about and a conclusion which summarises the lesson's content.
8. The teaching order appears logical.
14. Visits to outside events are sometimes arranged to broaden your knowledge of physics.
29. The teacher encourages discussion and speculation amongst the students.
11. To help you understand, films, filmstrips and filmloops are used as well as experimental demonstrations.
6. Individual homework and practical accounts are assessed and discussed by the teacher.
13. The lessons are planned to make experimental and theory work run smoothly.
1. Teaching is by lectures with experimental demonstrations.
36. Students are helped and encouraged to revise for the A-level exam in a planned way.
35. Individual or small group practical work takes place each week in a separate practical lesson.
10. The teaching style encourages the interest of the student.
32. Practical work is designed to help the student understand the knowledge from theory lessons.
12. Students' practical work is related to recent teaching lessons.

Table 9.5.10 shows that it is rare for the teacher behaviours expressed by these items to satisfy the demands of the students, with some notable exceptions for the members of type II. A much more effective match would enhance the performance of type II students and improve classroom outcomes for types IV and V. On the evidence of this study, there would be no adverse effect on types I and III.

It is easy to see how some of the items of the planned 'method' scale could be interpreted by an experienced teacher in a 'philosophical' manner to create conditions in which the students' understanding of the meaning and nature of the subject could develop. Particularly, the appearance of the open-ended discussion, vists and visual-media items give the teacher the opportunity to create a 'philosophical' atmosphere around the course material. Type III students would be expected to respond positively in such a class, which would also be attractive to the 'intellectuals' of type II. The philosophical approach has a slight negative correlation with attainment for type I students, which would appear to put the teacher in a dilemma. Either a 'philsophical' environment is created to help types II and III students; or, to help type I, it is not. Where there are competing curricular demands, evidence from the nature of the subject itself, arguably, should be the arbiter. From the work of Capra (1975) and Zukav (1979), there is little doubt that study of modern physics calls for a creative imagination and an awareness of the interaction of man and the physical universe. This points to the need to begin to develop in the sixth form, the 'subject nature' approach to physics for those students with sufficiently well developed cognitive styles of formal reasoning (Shayer and Adey, 1981). Such an approach would encourage type II and type III students, of course, and the less environment dependent type I students might have to come to terms with a more philosophical, process treatment of physics. Taking this line of discussion further, Zukav has distinguished between 'scientists' and 'technicians':

> "The fact is most 'scientists' are technicians. They are not interested in the essentially new. Their field of vision is relatively narrow; their energies are directed to applying what is already known. Because their noses often are buried in the bark of a particular tree, it is difficult to speak meaningfully to them of forests."
>
> (op.cit. p.36)

It is tempting to identify type I students (two-thirds expressing applied science intentions) with Zukav's 'technicians' and type II students with the 'scientists'. It is from the ranks of the latter that Zukav's 'complete' physicists, the 'Dancing Wu Li Masters' are drawn.

Zukav's 'Wu Li Masters' are able to see and appreciate the meaning of physics all the better for an historical perspective. The consensus theory of today is viewed as a culmination of historical events. This approach is positively associated with A- level physics attainment for type III students. It is, thus, strongly recommended that teachers present sufficient historical material in their courses to aid the students of this type. While some teachers might question the worth of such an approach for all their students, it seems that if due regard is paid to item 29 on the logical, 'method' teaching scale, namely

> "The teacher encourages discussion and speculation amongst the students",

then, the discussion period might be so structured as to provide the historical examples that would satisfy the type III students.

The almost certain heterogenous nature of an A-level physics class warns against a single narrow approach to the teaching of the subject material. In so far as it is safe to employ any one broad method to the exclusion of others, the current research has strongly suggested that the expansive, planned, logical, approach is best. This method implies sufficient flexibility to accommodate the needs and improve the performances of students of both types IV and V. However, in these instances, the teacher must be prepared to be much more prescriptive and might well consider:

a) restricting the amount and nature of the subject material to reduce the cognitive demand on these students;

b) setting aside additional tutorial time to assist with learning difficulties;

c) for type IV, defining as precisely as possible relevant out-of-class activities (syllabus-boundness is a virtue for these students);

d) for type IV, supervising examination revision and preparation, and

e) for type V, integrating practical work more meaningfully into the theoretical course (learning-by-experiment is a positive attribute).

This solution for types IV and V, while not encouraging the development of Zukav 'masters', is arguably the more realistic one for these lower achieving students.

A differential approach to teaching is an almost inevitable consequence of the identification of pupil stereotypes. It is encouraging to see here at A-level, as indeed was the case at O-level (Section 7.11), that this is possible within an overall teaching strategy which allows for particular 'option' methods. In effect, the sixth-form teacher recognises the broad five stereotype groupings and then prepares appropriate, individualised learning schemes based upon the planned, 'method' core of behaviours.

It will take time during the sixth-form course for the student types to emerge. No evidence is available from the present research as to when the stereotypes first become recognisable, but intuition and experience suggest that this will be well before the end of the first year of the course. Up to that time, the teacher will have established a planned,'method' learning environment base suitable for subsequent modification when the circumstances demand.

To allay fears and suspicions when introducing the recommended variations, the students should be fully consulted in drawing up their own 'learning specification'.

It is naive to hold the view that students are innocent of the relative abilities and attitudes of their fellows and desirous of identical treatments: the present research has demonstrated clear differential effects. It is the job of teachers of physics, as teachers of a science, to apply science to their method of instruction and to allow their students to see physics as a mastery of knowledge of the physical universe with both philosophical and humanitarian meanings (Bondi and Capra).

> "I propose that science be taught at whatever level, from the lowest to the highest, in the humanistic way. It should be taught with a certain historical understanding, with a certain philosophical understanding, with a social understanding in the sense of the biography, the nature of the people who have made this construction, the triumphs, the trials, the tribulations."
>
> [I.I. Rabi, Nobel Laureate in Physics, Rutherford et al., 1975, p.v]

9.6. TESTING THE HYPOTHESES FOR THE SIXTH-FORM STUDENTS

The evidence collected in this Chapter and in Chapter 5 allow the hypotheses of Section 3.3 to be tested.

Hypothesis 3.3(a)

Sixth-form physics students find the physics course

i) difficult,

On the evidence of tables 5.9.1 and 5.9.2 , this hypothesis is retained for both boys and girls. Girls find physics more difficult than boys at both lower sixth-form and upper sixth-form levels.

ii) enjoyable,

From tables 5.9.1 and 5.9.2 , this hypothesis is retained for both boys and girls. Boys find the subject more enjoyable than the girls at lower sixth-form level but this difference disappears in the upper-sixth.

iii) low in philosophical content,

This hypothesis is retained for both boys and girls on the evidence of tables 5.9.1 and 5.9.2.

iv) low in historical content,

In so far as historical content is measured by scale construct 2 in tables 5.9.1 and 5.9.2 , this hypothesis is rejected for both boys and girls. Physics acquires a 'historical' rating in both years of the course.

v) low in social implications content,

On the evidence of tables 5.9.1 and 5.9.2 , this hypothesis is retained for boys only. It is rejected for girls, who hold neutral attitudes in both the lower- and upper-sixth.

Hypothesis 3.3(b)

Sixth-form physics students display a fall in enjoyment as the physics course progresses.

Section 9.2.1 shows that this hypothesis is retained for the boys but rejected for the girls. Girls' enjoyment has been found to remain stable over the duration of the course.

Hypothesis 3.3(c)

Sixth-form physics students ascribe the characteristics in 3.3(a) and 3.3(b) to their course according to the examination board controlling the syllabus.

Evidence is presented in Sections 9.2.5 to 9.2.7. The hypothesis is retained for course difficulty, enjoyment and deterioration in enjoyment. The Oxford course is the easiest for boys and the A.E.B. course for the girls. The London course is the most enjoyed, and is the one most likely to maintain initial enjoyment.

The hypothesis is rejected for historical content, social implications and philosophical impact. No significant differences have been found between the different courses.

Hypothesis 3.3(d)

Sixth-form physics students prefer to learn in a varied environment, where experiences include verbal, experimental and multi-media learning techniques provided under a strong teacher guidance element.

The identification of a specific factor describing this varied learning style defined by the items in Section 5.11.4(a), and compared with other aspects of classroom management (tables 5.11.1 and 9.4.1) causes this hypothesis to be retained for both boys and girls.

Hypothesis 3.3(e)

Sixth-form physics students, if anxious, display fear-of-failure motivation.

On the evidence of table 9.3.8 , this hypothesis is retained for the boys but rejected for the girls.

Hypothesis 3.3(f)

Sixth-form students if syllabus bound, display no particular study habits characteristic.

From tables 9.3.2 , this hypothesis is retained for boys but is rejected for girls. Girls with high syllabus boundness scores tend to have poor study habits.

Hypothesis 3.3(g)

Sixth-form physics students who have the highest achievement as measured by the G.C.E. A-level physics grade,

i) display the strongest subject enjoyment,

On the evidence available from table 9.2.6, this hypothesis is retained for boys but rejected for girls. No significant attainment/enjoyment relationship has been identified for the girls.

ii) find the subject easiest,

This hypothesis is retained for boys only (table 9.2.6). No association between attainment and easiness has been found for girls.

iii) have the strongest academic achievement motivation,

The evidence from tables 9.2.3 and 9.3.4 permits this hypothesis to be retained for boys but rejected for girls. The girls display no significant association.

iv) have the strongest intrinsic motivation,

This hypothesis is retained for boys but rejected for girls, who display no intrinsic motivation/attainment link.

v) display no particular extrinsic motivation characteristic,

This hypothesis is retained for both boys and girls (tables 9.3.3 and 9.3.4).

vi) have the lowest fear-of-failure motivation,

The evidence from tables 9.3.3 and 9.3.4 is that this hypothesis should be retained for girls but rejected for boys. The boys fear-of-failure motivation is not significantly associated with attainment.

vii) <u>display no particular syllabus-boundness characteristic</u>,

This hypothesis is <u>retained for both boys and girls</u> (tables 9.3.3 and 9.3.4).

viii) <u>have the best study habits</u>,

Section 9.3.2 and tables 9.3.3 and 9.3.4 provide the evidence that permits this hypothesis to be <u>retained for the boys but rejected for the girls</u>. Of all the S.S.R.C. variables, study habits show the weakest association with attainment for girls.

ix) <u>are taught in a learning environment where student preference is matched by reality</u>,

This hypothesis is <u>rejected for both boys and girls</u> (table 9.4.2). There are no significant attainment/'match' relationships.

x) <u>are taught in a learning environment where varied experiences, including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element</u>.

There is no support for this hypothesis from Section 9.4.3 as an experienced classroom teaching method. The hypothesis is <u>thus rejected for both boys and girls</u>. However, high achieving girls express a strong preference for this method (table 9.4.5).

<u>Hypothesis 3.3(h)</u>

<u>Sixth-form physics students show the strongest</u>

enjoyment when taught in a learning environment,

i) where preference is matched by reality,

This hypothesis is retained for boys but rejected for girls, who show no significant enjoyment/'match' association (table 9.4.2).

ii) where varied experiences including verbal, experimental and multi-media learning techniques are provided under a strong teacher guidance element.

This hypotheses is retained for boys but rejected for girls, for whom there is no significant association (table 9.4.8).

Hypothesis 3.3(i)

Sixth-form physics students, whether boys or girls, show similar attitudinal relationships.

The evidence from the preceding hypothesis tests is that hypothesis 3.3(i) must be rejected.

Hypothesis 3.3(j)

Sixth-form physics students comprise a number of recognisable stereotypes for whom achievement and enjoyment outcomes can be characteristically predicted.

Five recognisable stereotype groups have been identified in Section 9.5 showing distinctive attitudinal patterns as typified by table 9.5.4. This hypothesis is thus retained.

As Section 9.5 has used the characteristic behaviours of the stereotypes to build up a clear plan for the most effective teaching of the students, little is to be gained by applying the general hypotheses explicitly to each stereotype cluster. However, these general hypotheses (3.3a to 3.3i) permit a broad overview of events in A-level physics classrooms. Hypothesis 3.3(j) serves as a reminder of the fine-structure and Section 9.5 supplies the subtle detail that the teacher or innovator then has to consider.

CHAPTER 10

RESEARCH SUMMARY AND CONCLUSIONS

10.1 THE CURRICULUM RESEARCH CYCLE

The 'provisional' solution of the curriculum research cycle of Section 1.5 has now been reached. The aims of Section 1.7 have been subject to investigation and the results have been reported in Chapters 6, 7, 8 and 9. It has proved possible to test all the research hypotheses. The status of these appear in Sections 6.3, 7.13 and 9.6. They are summarised below in Section 10.2.

The affective domain of behaviours has been shown to be generaly associated with attainment, in physics education. Typically, up to about 25% of the variance in attainment scores (a correlation of 0.50) can be 'explained' by the attitudinal variables (table 7.11.22). However, the variables which have the strongest effect vary from one pupil stereotype to another.

In the 'evaluation' stage of the research cycle, the typological structure of pupil types, teacher types and class types should be subject to tests of validity. Are they natural artifacts, as they appear, or statistical phenomena? If the former, the results of this research become part of the 'curriculum energy source' for subsequent investigation, possibly in terms of particular stereotype groups only. For instance, it is reasonable to expect physics teachers to be able to identify the disillusioned, O-level 'peak' physicists. Specific hypotheses relevant to this sixth-form group can be generated from the present research results, and the curriculum cycle used to test either learning experiences, content or both, with a large sample of this one student type.

10.2 THE MAJOR FINDINGS

1. Five student stereotypes have been identified in the upper-sixth form. The two above average physics achieving groups are either content oriented (almost exclusively male) or process oriented (a majority of girls). For the latter, the course has a philosophical impact. The third group, also with a majority of girls, comprises students 'pressed' into studying the subject. Historical and philosophical approaches go with success for this third group. The two lowest achieving groups are almost entirely male. One student group entered the sixth-form with high hopes but encountered severe cognitive difficulties. The other group entered with poorer attitudes, was exposed to a mis-matched environment, and suffered further in both attitudinal and achievement terms.

2. An overall teaching style described as planned, logical 'method' teaching, can maximise achievement and attitudinal outcomes for four of the sixth-form groups. The use of discussion techniques should permit the development of historical and philosophical aspects of the course, which appeal to the largely female groups. Flexible

lesson planning is needed to allow the low achieving groups to learn under supervision in the most compatible environment.

3. A-level physics is found, generally, to be difficult but enjoyable. Enjoyment deteriorates during the course for boys but remains stable for girls. Enjoyment is most likely to be maintained by students following the London G.C.E. course. It is easier to get high grades when taking the Oxford course, but is more difficult if the A.E.B. examination is used.

4. Attainment in A-level physics generally correlates significantly with enjoyment for boys but shows no association for girls. At O-level, there is a significant attainment-enjoyment link for both girls and boys, and it is stronger for the girls, too.

5. At both fifth-form and sixth-form level pupils prefer to learn in a varied environment where experiences include verbal, experimental and multi-media learning techniques provided under a strong teacher guidance element.

   Girls taught in such an environment in the fifth-form display superior O-level physics attainment,but there is no relationship for boys at O-level, neither is there any attainment-environment association in the sixth-form.

Enjoyment is enhanced when the teaching is of the varied type. This is true for boys at A-level and for both sexes at O-level.

When the learning environment matches the pupil's preferences, enjoyment outcomes are superior for both sexes at O-level and for boys at A-level. There is no attainment-match association at A-level but at O-level , girls do better in a matched classroom.

6. In the fifth-form, physics is found the most difficult of the common academic subjects. Amongst A-level physics choosers, physics is either the most difficult (girls) or the second most difficult subject (boys).

7. Subjects freely chosen for A-level study are likely to be those most enjoyed in the fifth-form. When reminded of practical and career limitations, physics becomes more 'popular'.

8. A-level physics is chosen primarily for career reasons. It is rejected because of the difficulty of the O-level course and its uninteresting nature.

9. Seven pupil stereotypes have been identified in fifth-form classes. For five of these stereotype groups, the varied, teaching-for-understanding approach is recommended to maintain and enhance attainment and attitudinal outcomes. For two of the groups an increase in the proportion of pupils going on to study A-level physics might be expected. For two of the low achieving groups, a flexible classroom organisation is recommended to permit a more individualised approach to learning.

10. A distinctive factor pattern underlies teachers' perceptions of effective teaching behaviour. This has permitted the emergence of seven teacher stereotypes.

11. Fifth-form classes themselves demonstrate a distinctive typology. A group of 'optimum outcome' classes has been identified who are taught by 'model' teachers, defined by the need to teach a planned, experimental physics which makes the nature of science clear, is pupil oriented and based on a theory of learning.

    The two most successful stereotype groups in the fifth-form are likely to be found in the corresponding upper-sixth groups. The high achieving, environment independent group ('natural physicists') from the fifth-form tends to split along cognitive lines in the sixth-form, and the lower achieving sixth-form sub-group then requires a greater degree of teacher support.

12. The Lie scale of the Eysenck Personality Inventory measures a quality associated with the characteristics of stable introverts (an organised code of social behaviour) rather than a propensity to lie.

10.3. IMPLICATIONS FOR THE TEACHERS

The major implication for physics teachers from the present research lies within the establishment of the pupil typology in fifth- and sixth-form classes. Treating a class as a homogeneous unit without acknowledging the variability in the learners' needs is almost certain to handicap one or more of the stereotype groups. While one of the high achieving groups (the 'natural' physicists in the fifth-form and the 'mathematical physicists' in the 'sixth') tends to thrive regardless of the environment at each level, the degree of success achieved in the class as a whole depends upon the support the teacher is prepared to give to the other stereotype groups.

The varied, teaching-for-understanding or planned 'method' approaches permit suitable experiences to be provided for most of the stereotypes. A structured classroom with learning logically ordered, using experiments where appropriate and supported by audio-visual media under the benevolent guidance of the teacher, has appeared as an optimum approach capable of satisfying the needs of most of the pupils for much of the time. At sixth-form level, discussion sessions allow the flexibility, which is essential for teaching some of the groups, to be naturally introduced. In the fifth-form, two groups, the 'good-time, low achieving extraverts' and the 'well-adjusted poor achieving leavers' either require special provision within the classroom or direction to a less academic form of the subject.

The identification of a factor pattern of teacher attitudes, and the association of classroom outcomes (pupil mean scores) with the most desirable attitudes towards the nature of science and its learning, suggests the worth of a sound teacher training, and points to the need to extend in-service professional studies to allow teachers the necessary time for reflection and analysis of their current classroom practice. Such courses should permit the nature of science to be examined while evaluating the learning theories that can be used to teach it.

Most of the research reported here has been concerned with the measurement of pupils' attitudes. Tests, some after modification, have been used to assess attitudes reliably. The fact that this can now be done adds to the power of the diagnostic services that the teacher can call upon. Attitudes and attainment can show a significant association. Thus, it is the duty of the teacher to be aware of the impact of his classroom teaching on the perceptions of his pupils. To do this, tests, chosen from those presented within this report, should be selected as appropriate. Teachers are likely to find the pre-test/post-test design for the sixth-form course particularly useful.

10.4 IMPLICATIONS FOR THE PUPILS

Pupils have indicated, for the most part, that they wish their teachers to play the key role in guiding their studies in physics. Therefore, the pupils' role in moving towards success at A-level would appear to be purely one of reaction: reaction to the environment imposed by the teacher. However, in addition to cognitive ability at the fifth-form level, motivation to succeed in academic subjects (or just in physics) has probably the strongest influence on attainment. If a pupil can be persuaded that he or she needs to do well in physics, either to demonstrate intellectual mastery over a generally acknowledged difficult subject or to enter the sixth-form as the first stage of a science-oriented career, then the teacher's problems are reduced. It has been suggested that all pupils should be given the chance to succeed at some level in physics so that an accomplished task-motivation reinforcement link can begin to operate. The responsibility here for the pupil is to ensure that he or she selects tasks within the classroom that are capable of successful completion. In other words, pupils are expected to display initiative and to take an active role in their learning.

Pupils as well as teachers should recognise the existence of different pupil-types requiring different levels of support in the classroom. Evidence has been given of the perceived stratification of ability in classes, and how some pupils feel that the teacher concentrates on the most able learners. There seems no reason why the teacher at fifth-form level should not explain his technique for teaching the stereotypes in his class to the pupils at large. Pupils would then be expected to appreciate more readily the demands put upon the teacher. Classes showing a greater teacher-pupil rapport would be the expected outcome. In the sixth-form, students should be able to place themselves within the identified typology. Knowing that he or she is a potential type- IV, disillusioned, O-level 'peak' student might well encourage the individual to adopt the measures described in this report to attempt to move out of the category. The teacher would thus have a more highly motivated student who would be amenable to his suggestions for alleviating the situation.

10.5 IMPLICATIONS FOR A SCIENCE OF TEACHING SCIENCE

Sherwood Taylor (1949) described science as

> '(summing) up in a rational way a great part of our relation with the external world.'
>
> (op.cit. p.350)

The clear typologies of pupils, teachers and physics classrooms, which the current research survey has identified, makes a powerful contribution to a rational explanation of events inside science classrooms (Section 1.6).

Since the conception and execution of the research reported here, Shayer and Adey (1981) have attempted, with a certain measure of success, to establish a model for learning science and to apply it through specific Science Reasoning Tasks. It has proved possible to allocate pupils to particular learning ability levels, ranging from the early concrete to the late formal stages. In the fifth-form, Shayer and Adey report that 70% of the pupils are still operating at the low level, concrete stage. They point out the need to match the cognitive level of the material being taught to the thinking level of the pupil. In this respect, the cognitive structures of a number of science courses have been analysed to show that they are often conceptually too demanding.

Shayer and Adey are able to show that a typical comprehensive school classroom in the fourth-year would contain a range of cognitive thinking styles. It is likely that the pupils who took part in the present survey would be mostly in the concrete/formal transitional stage, although it might be instructive to incorporate some

Science Reasoning Tasks in any future stereotype investigation to see if cognitive thinking style is a discriminating variable. There is already some evidence from the present research that this could well be true.

Typological analysis of pupil attitudes and attainment identifies natural clusters of individuals. These clusters respond to the environment of the classrooms in characteristic ways. Following the physical science model, if these natural clusters can be replicated in later research, the scientific base for teaching science will be further strengthened. At the present time, it is apparent that earlier, apparently inconsistent and imprecise findings (Section 2.8) could well be a function of the particular stereotype composition of the sample. Before the application of typological analysis, such a lack of precision tended to reflect harshly upon the scientific or psychometric approach to study of behaviours and attitudes, encouraging a trend towards more subjective research techniques (Entwistle and Wilson, 1977, p.15). Now, the existence of the clusters permits a precision of measurement previously lacking.

In order to smooth out some of the variability in human behaviour, even within clusters, large cluster sizes of several hundreds are desirable. Under these circumstances, psychometric measures would be expected to improve the precision of cluster descriptions and so enhance the scientific base for effective teaching.

An attempt can be made to mirror the physical sciences and build up an inductive theory. The steps would be

1. an identifiable typological structure of physics pupils (possibly displaying characteristic cognitive thinking styles - Shayer and Adey),
2. an identifiable typological structure of teachers (as defined by their attitudes and behaviours),
3. hypothesis formulation based upon the interaction of 2 with 1, above,
4. the testing of the hypotheses for the pupil-teacher interactions.

As well as replicating the cluster structures of the present study, it is clear that pupils' cognitive thinking styles and observed teacher-behaviours could be added in the next research stage to produce further validation. Hypothesis testing to establish a complete science teaching theory can then be conducted.

The position of the correlational studies in research into science education, which have not so far employed cluster analysis, must be one of a general summary nature. As long as the pupil or teacher sample is spread over the range of 'natural' stereotypes, the correlational results have a validity for pupil-mean or teacher-mean outcomes. However, care must be taken when acting upon such general findings if the potential population differs markedly from the typological structure of the sample.

Gardner (1975a) sees the essence of good science education in the way

> "...it should enlighten rather than confuse, clarify rather than mystify, liberate rather than dominate, and unleash creativity rather than stifle it."
>
> (op. cit. p.xvii)

This report has shown how teachers might reach this goal. It also demonstrates that the same goal of a clear, creative science for the techniques of communication is a possibility. That goal has not yet been reached, but the journey is well under way.