CURRICULUM PLANNING AND DECISION MAKING
IN TWO INNOVATORY COURSES IN HIGHER EDUCATION

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(in partial fulfilment of the requirements of the PhD degree, University of Surrey, August 1975)
Evaluation of innovations in curriculum seeks to provide information relevant to the improvement of educational provision. This is not only specific to the innovation, but more importantly, general in respect of the scope of provision as a whole.

Two case studies of evaluations of innovatory courses relevant to the national setting are presented. They are evaluated in terms of their provision of information for the various decision making audiences of the reports. This meta-evaluation highlighted the importance of developing an adequate evaluator - decision maker interface. An 'extended team' approach is proposed and tested as a solution to the interface problem. The professional roles and responsibilities of the evaluators and decision makers within this team are described.
This thesis is organised into four distinct parts, which are self-contained in the numbering of pages, tables and figures and separately referenced.

Part I introduces the work, reviews the literature of curriculum evaluation and the methodology adopted in the two evaluation projects.

Part II is the first evaluation project case study reviewed; the report to Schools Council on the 'Switch to Science' Course.

Part III is the second evaluation project case study reviewed; the report to the University Grants Committee on the Teaching and Learning Course.

Part IV contains a meta-evaluation of the two case studies analysed in terms of the information provided for the various decision making audiences of the reports. It contains recommendations for the development of evaluation methodologies which have been developed in the light of the shortcomings of the two evaluation studies. These have been tested and refined in two further evaluation projects presented as short case studies.
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Part I introduces the two evaluation projects in terms of the rationale and evaluation strategy adopted. It presents the background to each project and the links between them in relation to this work. It reviews the development of evaluation paradigms and strategies, two recent examples of which are applied in this work.
1.1 **Introduction**

This thesis presents the results of investigations carried out in the years 1969-1973, into two courses offered in the University of Surrey. i) The first was the common first year of a 'suite' of honours degree courses in Science and Engineering subjects offered to students with a predominantly Arts background. The 'Switch to Science' research project was supported by a grant from the Schools Council (1969-1972).

ii) The second was a short course in Teaching and Learning in Higher Education, for new and inexperienced teachers in mathematics, science and engineering subjects from Universities and Polytechnics. The 'Teaching and Learning' research was supported by a grant from the University Grants Committee (1972-1973).

It presents the information derived from studies of the two courses and highlights some of the issues and problems which emerged during the course of the investigations in the light of current theoretical viewpoints. In particular it examines the role of the curriculum evaluator as a provider of information to a wide variety of audiences to meet a diversity of needs.

Although the courses are clearly different in many fundamental respects, they and the associated investigations have a number of important features in common. These are briefly outlined in 1.11 and treated in greater detail in 1.4.

1.11 **Common features**

i) Both courses studied were offered in and on behalf of the University of Surrey by the Institute for Educational Technology (I.E.T.), a young and small Research Institute.

ii) Both investigations were sponsored by a funding agency independent of the University, which perceived the research in a broad national context, beyond local course development needs.

iii) Both courses were recent innovations (1967, 1968 respectively) in the context of a broad concern to meet important national needs.

iv) For each of the courses, there were few courses offered in the United Kingdom which were working to similar ends, none being closely similar.

v) The course administrator was in each case the course innovator and the project director.
1.2 Switch to Science Project

This research was supported by Schools Council in the context of the Dainton Report (1) and of an on-going discussion between Schools Council and the Standing Conference on University Entrance (2) about broadening 6th form education.

The former had drawn attention to the probable effect of early specialisation at school of student choice of subjects at University and had strongly suggested that it was one of the reasons for the observed 'swing from science' (3).

The University of Surrey at that time was, however, attempting to contribute to a counteraction of this swing from within the present system, by making special arrangements to take students from the Arts sixth form into courses which had hitherto required qualifications on the science side. These were in the first year of the honours degrees in

(a) Human and Physical Sciences;
(b) Physics B (started in 1967); Electronic and Electrical Engineering B, Metallurgy and Materials Science B, Physical Sciences B (all started in 1970); Biochemistry B (1971) (all B courses being one year longer than

* That is, by virtue of substantial experience in science teaching at the level of the first course, and of initial teacher education, I could discuss subject matter with course teachers as an equal.
qualifications).

These courses have been discontinued since the completion of the project studies.

The Human and Physical Sciences (HPS) course was a balanced course in which students studied pure and applied physical sciences together with human sciences. The first year of this course was designed to bring students of very different subject backgrounds to the point where they could be taught together. In this case mathematics, physics and chemistry courses were offered to those students without the appropriate A level (or equivalent).

The group of B courses was designed for students with at least a predominantly arts background. They commenced with a year common to all the courses, known as the Introductory Science Year. In this they followed courses in mathematics, physics and chemistry, in the main together with HPS students. These courses aimed to reach, from generally less than 0 level, a standard which allowed students to follow science courses during the subsequent year, alongside students with more traditional entry qualifications. At the end of this first year, students could transfer to other Surrey courses which required an equivalent preparation particularly in mathematics and physics.

The implications of these courses did, however, go beyond that of an interim remedy, itself a significant problem of curriculum. They approximated in length and subject content to the 'reduced A levels' of the kind that had been suggested both by the Dainton Report and the S.C.U.E. Schools Council Report, although they were of course geared to university population. Thus it was expected that the experience gained from the operation and study of these courses could be of considerable value to sixth form curriculum development.

However, the complexity of the HPS course, which involved a broad integrated course and a wider course in human studies in the first year than the three courses listed, led to an early decision not to investigate this particular course.

It was therefore proposed to undertake an operational study of the B courses, to involve:
(a) a factual study of the type of student who is attracted to the course;
(c) a study of methods for bringing students of diverse scholastic backgrounds and attainments to a common basic standard in science;
(d) an investigation as to how far the courses rely on features peculiar to the University of Surrey and how far they would have to be modified to be generally suitable for universities and colleges.

In addition, it was later agreed that, where feasible, assistance in the development of the courses would be given, where required, or where appropriate to (b) and (c) above.

1.3 Teaching and Learning Project

The Committee of Vice-Chancellors and Principals, in response to a report (4) from a working group with members from the Committee, the UGC and the AUT, set up a co-ordinating committee to assist in the development of University teacher training. The group had noted the general provision in Universities of some sort of training programme for their staff, but had agreed that the time was right to recommend the formalisation of training at local, regional and national levels. They suggested that this should not only include arrangements for induction to University and department, but also encouragement to attend an initial subject-area-orientated training course, followed by continuing guidance, by a nominated experienced member of staff in each department. They suggested that this last provision should be co-ordinated by a person with special responsibility for keeping in touch with developments in teaching and learning and advising departments in this. They also suggested both subject-area-orientated and multidisciplinary advanced courses for the further development of staff or for those undertaking the special responsibility above.

During the time the Working Party was deliberating, the University Grants Committee decided to "set aside a small amount...to provide special finance for university projects in (the Training and Development of University Teachers and Administrators)". This money was to 'be used selectively' for projects 'which might be expected to have a reasonably wide impact', which met certain criteria. These were 'that they should either exemplify new and diverse approaches, reach particularly influential people or effect a number of Universities or all three...whether (involving) administrators or teachers'. They further emphasised the experimental element of any courses offered for study, expected 'appraisal of the effectiveness of the
experience, required an inter-university element (possibly involving inter-university collaboration) and if possible, work involving 'high-level academic and administrative staff'. In this, the UGC stressed the possibility of 'follow-up investigations' (5).

The University of Surrey research proposal noted the shortness (6,7) and conservative influence of the majority of courses and that the few courses introducing new ideas were adversely affected by the later circumstances of new teachers. The research proposed matched the later suggestions of the Working Party report most closely, suggesting (as an interim measure until longer periods of training were accepted) courses of three types, one of each to be offered at Surrey and be the subject of a research investigation.

The courses were as follows, the first two being designed primarily for teachers of mathematics, science and engineering.

**Course A**: a course aimed primarily at new and less experienced teachers in Higher Education, but attended by members of Course C below, to aid discussion, observe the course in action and gain experience of developments in teaching and learning.

**Course B**: an intensive workshop course in a specialised topic (in this case Objective Testing) primarily for more experienced teachers, but also offered to those attending Course A.

**Course C**: a seminar aimed at senior teachers and administrators, on teacher training, evaluation of teaching and institutionalisation of reforms.

The intention was to 'make comparative studies of other courses', the findings of which would 'influence the content of the course' and 'subsequently appraise the effects of this and other courses at Universities' together with 'the results of other (UGC sponsored) projects' (8). The former aim, however, received minimal attention, owing to the short time between the commencement of the project and the courses. The latter was restricted principally to a restricted longitudinal study of participants of Course A; though all members of Course C were consulted immediately before the course, and subsequent to it.

The project was extended in a dual half-time capacity for sufficiently long to observe the 1973 course. In addition, the research was continued by
1.4 The Research Context

1.41 The Immediate Context The I.E.T. has been set up in 1967 having as 'a first important area to be developed...research in Science Teaching in order to co-ordinate existing activities in this field in individual departments and to promote new ones on an inter-disciplinary basis...with special reference to problems in the University and Sixth Form....' (9)

Most of the initial work of this Institute was on a part-time basis until late 1968 and mid 1969, when there was a substantial increase (proportionately) in its full-time research and development capacity (including this author). The aim of the I.E.T. was always interpreted broadly, i.e., to mount such research as would contribute to curriculum knowledge of the broadest kind in the University sector (10), at the school-University interface (11) and for the Sixth Form (12). Thus, the initial research must be set in the context of a young Institute. It had a small library, growing slowly with contributions resulting from the searches of its members (often somewhat after original publication) and from the growing network of contacts with other curriculum workers. Its members' expertise was growing, not a little through the visits of experts. It had not at the time developed what might be considered its own distinctive theoretical approach, and its members worked in many instances from quite different philosophical and research standpoints. It had natural problems of establishing itself not only nationally and internationally, but also in its own Institution. This was particularly related to the acceptance of its expertise in what was a new discipline for the University, and to the provision of resources, especially work space (permanent eventually in 1974).

This 'political' framework of the University was of especial importance to the work of an Institute of this kind, bringing to bear intra-institutional forces which included resistance to specific practices, developments and trends. It was an essential part of the immediate context of the two research projects presented here, indeed crucial to the work of the first project. In respect of the two courses organised and administered by such a small 'department', the Institute was acting as an innovator in its own right, ostensibly in inter or extra-faculty activities, but also to protect and develop what could be seen as personal innovations and to increase the
chances of survival of two young and vulnerable courses. A secondary result of this led to the unusual situation of the research studies themselves being guaranteed.

The relationships in the immediate context may be represented diagrammatically as follows.

FIGURE 1a RELATIONSHIPS IN THE BROAD CONTEXT

<table>
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<td>Immediate context</td>
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<td>Broad context</td>
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<tr>
<td>1 = Switch to Science Project</td>
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<tr>
<td>2 = Teaching and Learning Project</td>
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<tr>
<td>Some important interactions</td>
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(These zones correspond closely with the levels of decision making suggested by Goodlad and Richter: societal, institutional and instructional (16))
FIGURE 1b  RELATIONSHIPS IN THE IMMEDIATE CONTEXT

KEY

- H.O.D.
- Evaluator
- Course teachers
- Other interested teachers
- Other teachers/workers

Some intra-institutional relationships affecting the evaluation research

Head of I.E.T.
vention to meet a particular need, but related to issues involving rather a more general debate. In each case, the innovation stemmed in part, as is quite generally true, from a dissatisfaction with and a questioning of existing practices (13, 14a).

In respect of the first course, problems had been created by the decline in popularity of physical sciences and engineering when the school leaving population was increasing; by a questioning of specialisation in the Sixth Form and by the emergence of new subjects and broader patterns of study both in school and in Higher Education eroding the relative rigidity of former positions in both spheres. Provision of places for students who preferred to think again about following a progression hitherto accepted as logical was a natural contribution to these issues. The debated 'reduced A levels' for increased student numbers implied that the specific choice of content and the teaching methods used in the 'switch to science' course would be relevant to this issue.

In respect of the second course, consideration of the problem of rewards for teaching in Universities, especially in career development; a growing concern for increased teacher effectiveness; the growing number of Universities responding to these by their inclusion of teaching in lecturers' contracts; the need to provide for a greater range of student aptitudes and interests in the face of changing patterns of student entry into Higher Education (14b) and concern about the restricted range of approaches used by teachers, led to a small number of initial teacher education courses, one being offered at Surrey.

The broad context of these researches implied that the information from these studies would be relevant to a number of groups of decision makers (see Figure 2). An important group of people not included in Figure 2 is the group of students actually participating in the course. These were arts students in the first case and academic staff in the second. Their main decision before the course, whilst potential students (audience 3v) is to attend. After the course they may encourage others to attend, but hardly through reception of the project report. The second group could, however, be encouraged, by reading about the work of other participants, to extend their own work. This is not considered here to be a strong enough reason for including them as decision makers; rather they received the reports as a matter of courtesy and respect for their contribution (Teaching and
<table>
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<tr>
<td>Funding body</td>
<td>Schools Council</td>
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<tr>
<td>(2) Secondary client</td>
<td></td>
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<tr>
<td>Course organiser</td>
<td>Professor L. R. B. Elton</td>
</tr>
<tr>
<td>(3) Other audiences</td>
<td></td>
</tr>
<tr>
<td>(i) Course teachers</td>
<td></td>
</tr>
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<td>(a) in I.E.T.</td>
<td>(a) in University of Surrey</td>
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<tr>
<td>(b) in Departments</td>
<td>(b) other contributors</td>
</tr>
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<td>e.g. Keele, Cardiff, Newcastle</td>
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<td>(a) in teacher education</td>
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<td>(b) potentially receiving students</td>
<td>and institution</td>
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<td>(v) Potential students</td>
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<td>staff in institutions of Higher Education</td>
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</table>
1.43 **Methodology** The range of people potentially affected by the research and changes stemming from it suggests the notion of primary, secondary and tertiary audiences labelled above as (1), (2), (3), the last group being 'virtual clients' for the research findings. It also raises the question of the practicality of these findings to each of these groups (15a) assuming appropriate dissemination. It thus implies a dual evaluative function of providing information relevant to course improvement and information relevant to the national context. Of these, the former is also very relevant to and part of the latter because issues of course design and improvement are closely related to the selection of relevant goals, target populations, processes, resources and to the underlying values affecting these selections (14c, 16a).

These needs led me to adopt a methodological approach for both studies, which was based on the operational study requirements of the first project. This approach has been increasingly propounded and adopted (14d, 15b, 66, 17, 18a, 19a) as an 'illuminative' and 'responsive' style which allows issues and problems to unfold during the life of the research, to be addressed in a variety of appropriate ways (15c, 20a). It will be considered further in 2.2.

Thus I embarked upon the studies, setting aside preconceived ideas other than the most general of conceptual frameworks and hypotheses (21, 22), i.e. that courses might or might not be achieving their intentions; that there might be outcomes not considered by course designers; that curriculum development is about people as well as subjects, involving their values which often conflict and that it involves decisions constrained by limited resources, allocated in a compromise of conflicting needs, both national and local.

In each case, I commenced with extensive informal interviews of past students of the courses, and followed this with similar interviews of staff, together with attendance of the courses as a 'quasi-student' (23, 24).

The participant observation approach and the emphasis on students as primary sources of information, together with my own viewpoint on educational matters made strict requirements of the research. Since 'teachers, like other people, often prefer their less brilliant activities to be quietly forgotten' (25), a non-critical, tactful and empathetic (26a) approach was
course and students of the second. This was important, for though it has been claimed that 'there are no...systematic and logical procedures to translate educational objectives into teaching processes' (27) there are agreed ranges of approaches which promote student learning in certain categories of objectives, motivation apart (28, 29). In addition, in respect of possible disturbance through the observation and interview techniques used, (especially in the first course) there was a requirement to 'attempt to be unobtrusive without being secretive, supportive without being collusive and nondoctrinaire without appearing unsympathetic' (18b).

In each case, therefore, I solicited and received a collaborative and non-directive relationship with students and with teachers, without which the approach could not have succeeded. This is gratefully acknowledged.

1.5 Overview

Part I of this thesis continues in Chapter 2 with a review of developments and trends in curriculum and evaluative research and arguments for the research style adopted in the two projects, which was to illuminate issues and problems related to decision making at various levels.

Parts II and III present the accounts of the two projects in approximately the same form in which they were presented to the funding bodies, but in slightly condensed form with minor revisions and re-organisations.

Part IV examines these accounts and the information and results presented in the light of the framework of Part I and attempts to critically evaluate their utility in respect of decisions which flowed directly or indirectly from the work. It concludes with suggestions for future methodological approaches to similar problems, some of which have been adopted in later work (30, 31) and indications of potential researches arising from the two studies.
Summary

Chapter 2 presents a review of the development of evaluation principles and practices together with an examination of the strategy applied in the two studies.

The development of evaluation springs from attempts to measure the educational process, initially being almost entirely through the use of standardised norm-centred general measures. Increased concern for education in ways of thinking and for attitudinal change, together with observations of curriculum projects designed to meet these concerns, led to a formalisation of the curriculum process which has proved most influential. This was the curriculum theory of Tyler (32) which 'put the capstone on one epoch of curriculum inquiry and, in so doing, dramatised the need for another' (16b). In this theory, evaluation is carried out using course-specific criteria for estimation of learning, i.e. the objectives. This approach is described and linked to later searches for a generalised paradigm of evaluation, which stemmed in part from the rapid proliferation of alternative curricula which arose from widespread innovation. In these searches, Cronbach (33) emphasised the need for 'durable relationships' and Stake (34) and Scriven (35) debated the evaluator's role in respect of judgements: they considerably extended the aspects of courses to be evaluated to facilitate judgements of worth as a function of evaluation role.

In a parallel, theoretical work (16), Goodlad came to complementary conclusions, particularly in respect of values, closely relating evaluation to the particular stages in their conceptualised curriculum process.

However, even in 1972 Parlett and Hamilton could write "confusion is engendered as rival proposals, models and terminologies are voiced and then rapidly countered. As a developing field of study, evaluation proceeds in the absence of coherent or agreed frames of reference" (18c). Nevertheless, such frames of reference are emerging. In particular there is an emphasis on models and strategies which in some way meet the purposes of multiple audiences and improve the rationality of educational decision making.

A particular decision making model is described (19). It is based on the philosophy that unless decision making results from evaluation, the evaluation is useless, and therefore the only sensible course of action is
decision making. Thus the evaluation criteria are to be established with
the decision makers. The evaluations of this thesis are themselves evalua-
ted (chapter 15) against this particular model.

A 'responsive' and 'illuminative' strategy is also described (17, 18)
in which evaluation is carried out using criteria or clusters of criteria
related to issues, the emergence of which is facilitated by a flexible
evaluation process, in which the evaluator has a great deal of choice.
This was the strategy adopted in the two projects described.

Some associated problems are discussed. These lead to specific pro-
posals for evaluation methodologies which are presented and tested in
chapter 16 and summarised in chapter 17.

2.1 The development of evaluation

2.11 Innovation Innovation in Education occurs quite generally as a
response to needs or unexploited opportunities, assessed or perceived. In
particular 'there has to be some grounds for dissatisfaction with the
present curriculum in order to provide a concept of the (curriculum) pro-
ject as a worthwhile activity' (35a). To generalise this statement the
notion of curriculum is taken to extend to the whole range of curriculum
choices available to cater for all needs, whether personal or societal;
professional or general.

Innovatory activities are widely recognised as stemming from such dis-
satisfaction, for example, Boulding, in developing revised laws of economic
behaviour, has described conservation as follows. 'We will do today what
we did yesterday unless there are very good reasons for doing otherwise.
The good reasons which are necessary if we do not do today what we did
yesterday are derived from dissatisfaction with what we did yesterday or
with what happened to us yesterday' (13).

This has been exemplified by the Saturday meetings of dissatisfied
A.S.E. members to reconsider and revise school science curricula to bring
them up-to-date. This work ultimately led to the national development pro-
jects supported by the Nuffield Foundation. The groundswell of opinion
about completely rethinking curricula has been given periodic boosts by
Government reports or legislation. For example, the Newsom Report (36)
which indicated the scope of the needs of 'half our future' adult citizens,
together with consequent proposed legislation to raise the school leaving
The power of these forces for change is indicated by the 'snowballing' of projects triggered off by the foundation of the Schools Council. As an example, a Working Paper (67) which represented in the main the response of one HMI to the same Newsom Report led to the Nuffield Secondary Science Project in which I was also involved.

2.12 Curriculum theory and evaluation The development of theoretical approaches to curriculum has ensued from critical observation and analysis of such innovations, particularly in the USA. It led to the publication of a small volume by Tyler (32) which has been one of the most powerful influences on curriculum development and evaluation practice over 3 decades. It set the scene for the development of theoretical evaluation approaches which can be clearly seen in the works reviewed later in this section.

In asking his four questions:

1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organised?
4. How can we determine whether these purposes are being attained?

he provided 'the practitioner with a rationale by means of which to examine his problems' (16c). This rationale is a consecutive and cyclical design process in which the answers to each question provide a basis for the subsequent questions, to lead to the development of a specific curriculum.

He suggested answers to these questions at a general level and proposed methods for bringing in educational philosophy; learning psychology; knowledge of learners, subject matter and society, into the curriculum process. These methods have been widely adopted in funded projects. He proposed that 'the process of evaluation is the process of determining to what extent the educational objectives are actually being realised...' (32a).

This emphasis on objectives (aims and objectives not especially distinguished) provided a useful focus for curriculum evaluation for the next 2 decades. Three particularly influential works stemmed from general interest in objectives as a prime input into curriculum development and evaluation (37, 38, 39).

Here it should be pointed out that whatever the position taken by theorists in respect of behavioural objectives (40, 41, 42, 43), assessment of student learning is always carried out using behaviours displayed.
plays of knowledge, understandings, viewpoints, judgements, intentions; attitudes towards subjects, issues, tasks, peers, other co-workers (teachers or students), or displays of skills. They are assessed in a range of teacher-student interactions ranging from formal situations, e.g. written or practical assignments, to informal meetings, e.g. discussion, ad hoc consultations near to or remote from the ‘classroom’, in which assessment of student choices of work patterns and interests is inevitable. The criteria adopted by teachers in their assessments are many and varied, contributing to the richness of the ‘learning milieu’ (18). Ideally, all such criteria can be made explicit, but since students are many and varied, and whilst minimum competences can be relatively easily specified (notwithstanding issues of reliability or validity in examination situations) the range of competences encouraged in the development of individual student abilities, and tolerated in respect of student choice, makes the complete specification of behavioural objectives a daunting task.

Tyler also emphasised the need to apply the results of evaluation as feedback in the recycling of curricula to ‘modify the curriculum in the direction implied by the hypotheses’ (checked as consistent explanations of evaluation data)... ‘to see whether there is any actual improvement in student achievement’ (32b).

His notion of evaluation relating to developing and developed behaviour was later clarified as formative and summative evaluation (35) and continued in a development based on the first Taxonomy (44).

Whilst he strongly emphasised evaluation against objectives, he sowed the seeds for later developments, by emphasising the need for checks at various points in the curriculum process, giving methods of checking not necessarily related to objectives. Thus since ‘teaching procedures involve a considerable number of variables’ (examples) ‘these... make it impossible to guarantee that the actual learning experiences provided are precisely those that are outlined in the learning units’ (the latter clarified by Goodlad as ‘learning opportunities’ (16d)) ‘Hence it is important to check that these plans for learning experiences actually function to guide the teacher in producing the sort of outcomes desired.’

He also pointed out that ‘any way (examples are given) of getting valid evidence about the kinds of behaviour represented by the educational objectives... is an appropriate evaluation procedure’ quite apart from pencil
and paper tests which had been given too much emphasis.

Similarly, defining objectives is an important step in evaluation (32c) in which evaluation is a 'powerful device for clarifying educational objectives' (32d), to be followed by identification of 'situations which not only permit the expression of the behaviour but actually encourage or evoke this behaviour'.

He made implicit suggestions of value choices in determining objectives in, for example, his suggestion of an analysis of contemporary life. This is 'because...it is very necessary to focus...upon the critical aspects of this complex life...(to avoid)neglecting areas...that are now important...' (32e). However, notions of curriculum derived from studies of school education need further elaboration and extension before application to higher education which requires 'knowledge of the demands of culture, society and the profession since higher education is concerned with the preparation of students for jobs as well as that more general notion 'life'. They also require information about...the nature of knowledge' (24b).

Further, the curriculum of general education should be 'so planned and organised that every student, of whatever ability or achievement, finds an appropriate educational opportunity.... This...idea...indicates that standards should be derived from the potentialities of each individual rather than from norms or from performance levels determined in some theoretical manner. What is wanted is that each person be the best citizen he is capable of being....' In contrast, 'each profession and vocation has within it certain levels of performance which have been achieved over years of development. The person aspiring to enter a profession or a vocation is expected by society to meet these professional requirements for performance' (56). Thus unless these minimum standards are met, it is not sufficient that each performs to the 'highest level of his ability'.

Tyler's suggestion that 'it is necessary to screen...objectives...so as to eliminate the unimportant and contradictory ones', was developed considerably, as was his notion of checks, in Goodlad and Richter's work (16). In it they concentrated on bridging theoretical and practical considerations (16e) and moved decisively towards the later decision-making models. They took as their starting point that 'curriculum is a set of intended learnings' and whilst commenting on the ends-means pre-occupation of curriculum workers they thus agreed with others (e.g. 45, 46) on the importance of decisions about ends in the formulation of curricula. They further
parison with the relatively mature field of linguistics (16f) or indeed any science or social science.

They delineated 3 kinds of decision phenomena:

1. values
2. aims
3. learning opportunities

and stressed that no clear logical process relates these together. Rather, they argued, conventional and funded wisdom must be systematically consulted through appropriate specialists or representatives in selecting the components of each and the links between them.

They elaborated particularly on the problem of values and stressed that in Tyler's first question 'the "should"...calls for an initial value position' (16a). They suggested that 'discrete ends must support each other and be perceived as means for achieving some overall end or set of ends', and emphasised co-ordination of and consensus in teacher efforts. Such rationality, they argued, is dependent on assessment of values at all stages, for 'rational curriculum planning seeks to produce valid and justifiable intended learnings' (16g). They further questioned and analysed the (here) underlined words, and suggested the identification of relevant data sources and screening processes.

Their analysis linked values, aims, objectives, learning opportunities and organising centres to each other, to conventional and funded knowledge, and to 3 levels of decision: societal, institutional and instructional.

They showed the inevitability of a dynamic cycle of curriculum change as a result of the increase of funded knowledge brought about by society's educated members together with the increase of the conventional wisdom of society's members, itself brought about by education, e.g. 'education generates new values' (the effects of other aspects of funded knowledge, e.g. improved communications, should however be added to this).

In defining curriculum as intents at all levels, they broadened evaluation to: observations of discrepancies between the curriculum and the actual transactions; explanations of discrepancies; checks at all points including authenticity and significance of alternatives, and rationality of choices making up the intents. Their conceptual system (Figure 3) thus shows both the derivation and evaluation of choices. To accomplish this, they recommend 'formal and informal checks at all major decision points so that
* Based on Figure 3 of Goodlad and Richter's work (16). The two-way arrows indicate both derivation and evaluation processes.
Thus 'evaluation takes on a rich meaning...it is a means of checking each step in the curriculum planning process; it is not just a terminal process of checking student performance.' It therefore provides a means of pointing out contradictions of values, insufficiencies in objectives related to aims, improvements in matching learning opportunities to objectives and so on.

They thus clarified many of the questions which were implicit, unanswered or even unposed in Tyler's short work.

2.13 Evaluation principles and models The development of evaluation models and theories continued in the search for a more general prescription than a curriculum evaluation which was 'the handmaid of curriculum research and development' and 'a narrow prescription for improving the curriculum'. This led to models which 'might be called educational systems evaluation models' designed to accommodate diverse activities (47).

In this respect, arguments against the comparative evaluation of curricula (33, 55) on grounds of complexity, came to be seen as theoretical, remote from the practical world in which comparisons and choices are made, decisions are made, indeed, have to be made by teachers and administrators. These inevitably involve comparisons between curricula and between elements of curricula, e.g. specific learning opportunities; between what is available and what individual teachers hold as ideal, leading them to decide to adopt or adapt or reject the elements or the whole. Thus '...understanding is not our only goal in evaluation. We are also interested in questions of support, encouragement, adoption, reward, refinement etc.' (35).

The question of judgements has been given much attention. 'Evaluation proper must include, as an equal partner with the measuring of performance against goals, procedures for the evaluation of the goals' (35c), a point now widely agreed. However, much argument has been expressed about what judgements are to be made and by whom. In distinguishing between the formative and summative roles of evaluation, 'Scriven has charged the evaluator with responsibility for passing (judgements) upon the merit of an educational practice' (34a). Others have not accepted this challenge and have included obtaining 'recorded personal judgements on quality and appropriateness...' at each stage of the curriculum process, as part of the data of evaluation.
philosophers, subject matter experts and the evaluators themselves (48) (author's underline), depending on the stage of development of the programme. They identified four such stages: Broad Objectives, Interpretations of each of these, Strategies of all kinds for these, and Outcomes.

FIGURE 4  A THEORETICAL EVALUATION MODEL (due to Taylor and Maguire (48))

Here 'Societal Press' corresponds to Goodlad's values, as it refers to those societal and professional pressures that lead to the statement of broad-category objectives which define the relationship between school and society (48).

The argument about the expressing of judgements has been taken to its logical conclusion by Lortie (49) who stated 'Persons and organisations cannot be trusted to act as judges in their own case'. He further suggested that fee-for-service evaluators could be employed to render the kind of public and disinterested accounting accepted in respect of the financial accountability of managers in commerce and industry. He also suggested a way to resolve 'issues of moral complexity stemming from ends-means ambiguities' by representing 'alternative value schemes, by statistical weighting schemes'.

Stake agreed with Taylor and Maguire in suggesting 'that judgements will become an increasing part of the evaluation report', but that 'evaluators
gathered objectively' (34b). He thus emphasised the responsible role of the evaluator in processing judgements and suggested this responsibility 'is much more acceptable to the evaluation specialist than one for rendering judgements'.

In attempting to introduce a conceptualisation of evaluation orientated to the complex and dynamic nature of education, one which gives proper attention to the diverse purposes and judgements of the practitioner, Stake clarified further the 'basic characteristics of evaluation activities (34c). He offered a framework of description and judgements which should be used to stimulate rather than subdivide our data collection' (34d). He called his categories: 'Antecedents', i.e. 'any condition existing, prior to teaching and learning which may relate to outcomes' (author's underline); 'Transactions', i.e. 'the succession of engagements which comprise the process of education'...including testing; and the 'Outcomes', such as 'the abilities, achievements, attitudes and aspirations of students resulting from an educational experience', both short and long term, together with 'the impact of instruction on teachers, administrators, counsellors and others' and such tangibles as cost (34e). These he divided into 'Intents' of all kinds including 'a priority listing of all that may happen', and 'Observations' including 'antecedent conditions and instructional transactions' as well as student and other outcomes.

In treating the processing of such evaluative data, Stake took the works of Tyler, Goodlad and Richter, and Taylor and Maguire further, by examining the relationships between each of his six proposed cells. These he called 'contingency' and 'congruence', especially clarifying the beginning work of Tyler in terms of these relationships for intents and observations.

In three particular aspects of the work of Stake and Scriven, there are ambiguities which, it will be shown, have been clarified by Stufflebeam et al (19).

Stake's 'Standards', in a rational curriculum process, it is maintained here, should be subsumed into 'Intents' at a judgemental level of decision-making about which details the evaluator offers critical comment drawn from appropriate sources, in order to meet 'the responsibility of evaluation... to make known which standards are held by whom'. It is, however, a clarification of elements of the funded knowledge and conventional wisdom of Goodlad.
Similarly in the matter of judgements, there is ambiguity in the role of the evaluator who 'must make a subjective decision...in the matter of selection of variables for evaluation' (34f). Clearly the expertise of the evaluator as a professional is brought to bear on judgements of how to obtain information; in attending to and noting discrepancies of all kinds between intents, observations and standards; in deciding on the kinds of intervention to be made during consultations, e.g. when to question values (at all levels), standards and intents; when to indicate the need to operationalise objectives, or point out the different possibilities of 'methods'. Thus judgement permeates evaluation, as it does any other professional activity.

In matters of judgement about a programme he states 'the judging act itself is deciding which set of standards to heed.... assigning a weight... a decision as to how much to pay attention to the standards of each reference groups in deciding whether or not to take some administrative action' (34g, author's underline). The weakness of this argument in favour of the evaluator judging, rather than assisting the decision-maker to judge, is confirmed by his footnote 'deciding which variables to study and deciding which standards to employ are two essentially subjective commitments in evaluation...beyond the reach of social science methodology'. In what way then does the evaluator have especial judgement rights?

That 'the countenance of evaluation should be one of data gathering that leads to decision making...' (34h) impinges on an ambiguity of Soriven's work, in his distinction between goals and roles, two ways he proposed of thinking about the aims of evaluation. He quite rightly challenged the roles evaluation has been required to serve and the consequent 'dilution (which) has sacrificed goals to roles'. In this he is putting goals higher than roles. Goals are expressed as answering certain types of question. How well does this new curriculum, method or teacher perform with respect to appropriate criteria? Is its use worth its cost? (35d) 'Does the programme under observation have greater value than its competitors?' (47) In answering these questions, the logical activity of evaluation is to gather and combine 'performance data with a weighted set of goal scales to yield either comparative or numerical ratings' (35e). Yet these questions can only be asked and the weightings carried out with some purpose in mind, namely to meet the needs of the evaluation project sponsor or those agreed
Evaluation and decision making  "Educational Evaluation is the process of delineating, obtaining and providing useful information for judging decision alternatives" (19b) is one of the most recent synthetic and general definitions of evaluation.

It is a general definition because it does not state for what points in the system decision alternatives should be delineated, nor does it indicate the kinds of information required, the basis of judgements, nor give guidelines for processes and procedures. It is synthetic as it subsumes previous thinking in the field of evaluation in its many aspects, whether overlapping or separately delineated.

It therefore presents an underlying philosophical basis for evaluative activities of diverse kinds, 'multi-faceted' (19c), as a continuing process, whether sequential or iterative, which defines needs and suggests alternatives to meet those needs.

The work as a whole encompassed and developed in a remarkably complete and thorough way the theoretical, strategical and tactical propositions of a great variety of evaluators and evaluation theorists, including those previously summarised. The work was set in a context which integrated what was known about decision-making on the one hand and evaluation successes and failures on the other in a comprehensive synthesis. It drew heavily on an important work (50) which explored the ways in which values and priorities are applied in real-life decision-making. This was particularly in respect of conflicting and complementary values, and the choice and ordering of priorities in the development of policies offering different combinations of benefits.

In this latter work, Braybrooke and Lindblom dismissed naive approaches and examined ideals, e.g. the rational-deductive ideal, in which value-ratings would lead logically to processes which ensured that all contingencies were weighed by a values-calculating process.

From the fundamental failure of analysts to operationalise one or other of the ideals they discussed sufficient for policy analysis, and from a synthesis of strategies of social evaluation they justified an approach to decision-making relevant to this work.

They proposed a system of classification of decisions relating the degree to which the synoptic ideal of complete understanding is achieved to
Making is in the low understanding - low magnitude quadrant, due to the difficulty of achieving high understanding and precision of prediction. They saw this as due to our limited problem-solving capacities; the inadequacy of information available at the time decisions actually need to be made; the cost of appropriate analyses and methodological problems amongst others. They described the principal strategy of decision in this quadrant as disjointed incrementalism, which is an operationally observable phenomenon.

![Diagram](image)

**FIGURE 5 DECISION MAKING SETTINGS (50)**

The translation of this work to educational decision making by Stufflebeam et al. set out the separate roles of evaluator and decision makers and the relationships between them. They also set out the effects of decision magnitude and information grasp on these roles, for which the evaluator's involvement is least in homeostatic, and most in neomobilistic situations.

They set out the complementary aspects of the roles and co-responsibilities, e.g. evaluators seeking 'to reduce the effects of... sources of irrationality in the decision process' vis-a-vis decision makers seeking 'to increase the rationality of their choices...' and the corresponding 'high level of professionalism' in the 'co-operative endeavours' (19d).

They proposed changes in these distinctive roles through the awareness, design and action stages of planning, structuring, implementing and recycling decisions. These kinds of decisions are identified with corresponding types of evaluation (19e) sketched very briefly below in comparison with the comprehensive goals, roles and methodologies described in the original.

**Context evaluation** is the most basic type and serves planning decisions by providing a rationale for determining objectives and by identifying potential methodological strategies. It identifies the relevant environment,
identifies unmet needs and unused opportunities, and diagnoses and ranks the problems that prevent needs from being met and opportunities from being used.

It is macroanalytic in monitoring the total system; overall it is systematic, yet ad hoc when diagnosing problems and needs.

The other three types of evaluation are specific and ad hoc; they come into play only after a planning decision has been reached to effect some sort of system change, and specific evaluation designs for each vary according to the setting for the change. Generally speaking, the greater the change and the lower the information grasp (decision makers' knowledge of how to effect the change), the more formal, structured and comprehensive is the evaluation required! (19f).

Input evaluation serves structuring decisions to determine project designs, assists in determining how best to meet selected goals, by identifying and assessing: relevant resources and capabilities; feasible and operational objectives; appropriate strategies, specific (course) designs for a selected strategy. Ideally, this should include cost-benefit analysis of alternatives.

It is microanalytic and essentially ad hoc. It questions appropriate process and product designs.

Process evaluation serves implementing decisions to control project operations. It provides feedback on the implementation of plans and procedures by assessing the extent to which procedures are operant as intended. It assists in their improvement and development: by predicting and monitoring continuously the potential sources of failures (including effects on teachers and adequacy of facilities); by projecting and servicing preprogrammed decisions such as school sampling, trials of materials; and by providing a record of the procedure. It thus includes some elements of Stakes' outcomes.

Product evaluation serves recycling decisions to assess, judge and react to project attainments, the most traditional sort of evaluation, whether using instrumental or consequential criteria (35) carried out during and after completion of project cycles. It includes making rational interpretations of outcomes using the information recorded from the other three types of evaluation.
They have clarified Scriven's goals-roles ambiguities: the goal of evaluation is to answer questions by obtaining and providing information; the corresponding role is to provide this information to increase the rationality of decisions (19g). Thus goal questions cannot be considered as independent variables and as having an intrinsic existence. Nor can they normally be answered by a paid evaluator without some decision-maker's funds (unless such evaluations and their goal questions had general institutional approval, whether as a normal part of teaching or of autonomous research). Thus, selecting and asking the questions are acts of the evaluation process, i.e. the joint task of delineation. This clarification removes Stakes' problem of 'selection of variables'. Goals and roles then, merge at the interface between evaluator and decision maker. Operation at this interface gives the evaluator his 'chief claim to a professional role in the traditional sense of a special and privileged relation to a client' (19h).

FIGURE 6 THE EVALUATOR - DECISION MAKER INTERFACE

Thus the distinction between formative evaluation, 'to serve as the basis for altering the nature of the programme', and summative evaluation, for use in making decisions about support and adoption, the proximate and ultimate aims of evaluation (47), is a distinction in the kinds of decision to be made as a result of the evaluation. This gives a special responsibility to the evaluator to ensure that the most important goals are indeed agreed and that the role is agreeable to him.

2.2 Strategies adopted in this research
2.21 'Illuminative' evaluation Stufflebeam has specified in great detail

* including the decision to postpone changes i.e. to delineate further information requirements.
reformer, or staff officer to the practitioner and the purpose of evaluation is to improve or change a program or practice, then, the process of evaluation is characterized by a client-centered orientation — in that the clients specify the objectives (usually with help from the evaluators);.... The intended result is decision and action! (20b). Stufflebeam's extreme position has been criticized by Scriven because of its 'bias towards the concerns and the values of the education establishment' (66a). It has also been seen to fail for school evaluation in the USA for two reasons: firstly a federal line-management concept of evaluation which would have caused any model to fail; secondly reluctance on the part of managers 'to examine their own operations as part of the evaluation' (66b). Nevertheless, the underlying concepts remain, for example the four evaluation types extend Stake's three categories, correlate highly with Tyler's four questions; with the Open University's Goals, Plans, Implementation, Development (64); and the first three types with Goodlad's 3 levels.

Another face of evaluation is: 'When the evaluator is seen as a neutral social scientist and the purpose of evaluation is information and analysis, then, the process of evaluation is characterized by an independent orientation — in that the range of inquiry includes but is not limited to the client's intended objectives;....The intended result is the provision of more complex bases for informed judgment' (20c).

This is more akin to Scriven's 'goal free evaluator... who goes over the ground very carefully, looking for signs of any kind of game' in contrast to the 'goal based evaluator' (51a).

This mode of evaluation has also been described as 'illuminative' (18), or 'responsive' (66, 17) as contrasted with 'pre-ordinate' (66c). The former is considered as belonging to the 'anthropological' (18d) or 'psychotherapy' (35f) research paradigm rather than being based on the psychometric traditions of educational research. It is proposed as 'a general research strategy' rather than 'a standard methodological package' (18f).

In the illuminative style of evaluating a course, 'its rationale and evolution, its operations, achievements and difficulties' are intensively studied 'in the school context or learning milieu' (18e). The evaluator familiarizes himself thoroughly with the day-to-day reality of the setting.. .. (taking)as given, the complex scene he encounters. His chief task is to unravel it; isolate its significant features; delineate cycles of cause and effect; and comprehend relationships between beliefs and practices and
Thus there is emphasis on case study rather than survey approaches, learning as a socio-cultural rather than a cognitive experience, processes rather than inputs and outputs... the programme as it is rather than as it ought to be' (52), and on 'understanding it as a working system' (53a).

Stake has taken a similar view, in suggesting that responsive evaluation is what people do naturally in evaluating things. They observe and react' (17a). 'The evaluator would pick and choose what to observe, what to record. He might not be wholly passive; he might find that what is needed requires intervention, stimulation. But he would arrive at that decision as a result of letting the program stimulate him' (17b).

In providing descriptions of the course and its processes, these authors stressed the variety of different approaches required and the special impact of case studies in faithfully representing and clearly communicating the course. These, for example, 'will be the narratives of how a few students were engaged by the (course), how they interacted with teachers and students, how they studied, what they learned, how they felt' (17c).

In the long open ended exploration phase of this type of evaluation the evaluator carries out extensive observation, talking and listening, being receptive to a mass of different information! to familiarise himself thoroughly with the day to day reality! and becomes knowledgeable about the total scheme! (53b). Consultations are extensive, as they would be in a decision-making model, for there are many who contribute to, become involved in, are affected by and are properly concerned about educational programmes; all such are potential data sources for evaluation. A heuristic list of such consultable role functionaries has been provided (19i).

This 'school based...research (takes) the phenomena and dilemmas, problems and practices...as (the) starting points...the investigator immerses himself in that world, tries to make sense of it, builds theories and explanations about it; he defines (or helps to define) problems where information is needed, confusion persists, or conflicting explanations pertain! (54). The emergence of these issues and problems leads to more sustained directed enquiry, in which 'interviews become more focussed, observation on classes more selective' (53c). 'These issues are a structure for the data gathering plan...the observations...contribute to understanding or resolving the issues identified' (66d) using any data gathering technique appropriate to
The initial unfiltered and the data itself combined: is the 'extensive database', reduced by 'progressive focussing' on unpredicted phenomena, is added clarification, interpretation and organisation, for the final stage of reporting. In this, the evaluator is sensitive to the needs of the audience, however multiple, in which 'many times he will want to provide a portrayal from which audiences may form their own value judgements' (66c).

Such extensive observation is widely acknowledged as providing the key to interpretation, e.g. by experts on the 'true' extent of individualisation (47), especially if it includes both 'exceptions and expected events'.. 'a record of problems and successes encountered that can be anticipated in future programmes' (19j).

2.22 The strategy adopted in this work

This was the strategy adopted in the researches, although it was not formalised as part of the literature until after their design. The choice stemmed from the proposition that the first project should be 'an operational study...' (see 1.2) which implied an intensive study of the course and how it worked, as it was, with its effects on all concerned, particularly the students. Additionally the small scale of the research, in terms of student numbers at the primary research site put a premium on the validity of the studies, which could not hide behind the reliability (spurious or otherwise) of large scale empirical studies of the traditional kind. There was also a fairly early influence by a paper (23) brought back from an excursion to M.I.T. during the early stages of the I.E.T.'s development of links with the established experts of the field to gain from their expertise. This work was very close indeed to the style already adopted: indeed some of the specific data collection instruments met the research requirements closely enough to be actually used, at least in part. An unusual feature (35g) of this work was that I had substantial teaching experience relevant to the courses studied (7 years in Teacher Education concurrent with 12 years of Science Teaching). Parlett in his M.I.T. study had observed that it was disadvantageous not to be conversant with the subject matter and my knowledge would be of great advantage (57). This was because I could predict learning difficulties more clearly and explore them more readily. However, as I generally rejected a formative, transactional mode of evaluation (see 2.23), the 'clashes and failures to communicate' (35h) were carefully avoided, though this was sometimes difficult.

Similarly, I took the students of both courses as primary sources of
should allow for the possibility of educational aims and programs being derived...with careful regard for learners as a data-source (16i; 24b) (especially true for the second project), and partly because it was clear to me that semi-participant observations of processes and discussions of intents would be valueless without the rich complement of student reactions (65).

Thus, I took description of the courses and of their effects and affects to be a particularly important requirement of the projects. Others were to be informed, others were to make decisions; they needed to see the courses as a whole, and not as a set of analytic portraits. The information provided would in any case be only a part of the whole for the two principal clients (1.42) who would need to synthesise reports and opinions from other projects and sources.

In each case, partly because of time constraints and partly to provide information which would direct my attention towards problems, issues, system blocks, possibilities for experiment and improvement, I consulted students at a very early stage. In the Switch to Science project, they were ALL the students currently in-course, in the last month of their academic year. In the Teaching and Learning project, they were a sample of participants of the two previous courses.

In the Switch to Science project, I asked students (individually) a range of questions about their motivation, expectations and successes, the relevance of school work and their observations of the course. These very loosely structured interviews were a rich data-source, indicating common problems, many corroborated in staff interviews. These problems became themes for investigation.

This led me directly to prepare experimental learning materials and tests for the following cohort. They became the focus of a longitudinal study initiated by my observing their selection interviews and continued by my attending a substantial proportion of the first year of their course. I interviewed these students and also staff after specific sessions in order to clarify processes and learning difficulties. I also attended all examiners' meetings and staff-student committee meetings. I interviewed members of departments into which students had continued (or might continue their course) as to their impression of the students and the course. I gave all staff and students throughout the period of the research regular interviews of between ten minutes and (usually) one hour duration, at least every
explore specific issues as they emerged. Student interviews were generally informal: after classes, over coffee or lunch; in bars; casual meetings on and off campus, sometimes in student study-bedrooms. I also interviewed all students of the 1967-1970 cohorts at length, at the end of each year of their course. I drew supplementary data from published and specifically designed tests and questionnaires, from examination results and from application forms. As far as possible I used more than one technique to cross-check findings. For example, I explored student motivation through interviews, observations at their selection interviews, data from application forms and from questionnaires, to effect 'triangulation' (18h, 15d, 58). Similarly I explored many of the learning difficulties which emerged during interviews in: test results; student reactions to specific materials or even some 'quasi-experimental' (15c) research into concept formation. In this respect I used some tests in a comparative evaluation with 'comparison groups' (59a, 35i).

Thus I aimed to get into the 'learning milieu', to know the students as people, as individuals, both inside and outside the classroom in the wider environment of a university, with its social facilities and life on and off the campus. This brought me into contact with students from other courses, and emphasised the need for a broad human involvement in the research, rather than a narrow clinical one. For if students might be describable in terms of certain characteristics, for every student turning from arts to science with a particular state or degree of one such characteristic then I could describe many others following a different course in the same way. This was as true of high or low motivation; ease or difficulty in studies; interests of all kinds, whether related to course subjects or not, and at whatever depth of interest; range of career planning, long, short or none; personal guidance, extensive or none, with implications for teachers in those other courses.

The large issue of student motivation led me to explore by questionnaire the extent to which careers teachers were aware of this and similar courses together with their attitudes towards 'switching-to-science'. I visited other courses and described them after interviewing course teachers (19k).

Thus I asked questions of the following kind:
Could students who had followed a condensed course achieve sufficient understanding to continue their course with profit?
Did the students have any special problems requiring special solutions?
Were their interests being maintained?
Did they require greater resources than other students?
Did they need extensive counselling?
Should it be provided?
Should staff be persuaded to modify their course material to be more attractive to students?
Were students accepted by teachers and peers?
Did they adjust easily in the first and second years?
Were the courses sufficiently well known?
How did school teachers view these courses?
What were the potential student numbers?
Did students come for the 'best' reasons?
Was there a likely transfer of the courses to schools?

In the Teaching and Learning project the early interviews highlighted problems of what were the desired and achieved changes in teacher behaviour as a result of a short course. An important contribution to this early orientation was made by those attending the parallel course C. From these interviews I drew up a set of potential course aims and converted them into a (pre-tested) questionnaire, which I used as a basis for analysing course achievement. Longitudinal interview data from the majority of participants supplemented this later. I made a similar emphasis of course description, drawn from attendance at the whole course, from extensive interviews with participants during the course, and from interviews with most of those who taught on the course. Thus whilst the course was considerably shorter in length, the basic strategy was very similar to that of the Switch-to-Science project.

Whilst I could not develop as close a personal relationship with participants in this case, nevertheless I could determine motivation in attendance; changes in interests; affects of the course and subsequent problems in Teaching and Learning, by establishing a non-critical interested relationship which even allowed me into participants' homes. In this latter work I made a more concerted attempt to examine the course aims and the extent to which these were met and accepted by participants (because of the shortness of the course). I made a lesser attempt to understand the wider framework of changing policy which controls the ways in which courses like this fit into the ultimate training 'schedule' and in which short courses may ultimately disappear in the context of developing curricula for the training of
Thus I asked questions of the following kind:
Are students' expectations fulfilled or changed and fulfilled?
How fundamental should the course attempt to be in respect of empirical psychology?
Did their thinking about educational issues become more fundamental?
To what extent should their thinking become more fundamental?
Did it lead to later innovation (14a) and experiment or to frustration?
Should new teachers attempt such innovation?
Do teachers (senior or junior) accept training courses?
Will short courses be seen as sufficient or lead to demand for longer or more advanced courses?
Should such courses be residential?
What are the expectations of senior teachers in respect of such courses?

In each project I used objective testing (or its equivalent). I did see this in fact as being 'compatible with the maintenance of the good personal relations necessary for informed observation and interviewing' (68). In the first project I always followed this by getting students to mark tests linked with the course and arranging for immediate discussion of the results with a teacher (often myself). In the second project I referred to questionnaires during interviews. Participants always accepted that their contributions were providing me with a helpful data source.

Thus the research methodology went beyond a kind of an instrumental evaluation equivalent to the scientific logical positivism, with its highly developed measuring instruments, which would ignore those aspects of the problems presented in the study which were 'intangible' or difficult to measure (191). It approached emergent issues and problems in a variety of appropriate ways (20a): descriptive, as in questionnaire, interview and observation studies, test-score analyses (but including anecdotal, subjective and impressionistic records (18i)); developmental, or longitudinal studies with several 'post-treatment' measurements; case studies of individuals and groups; correlational studies; and quasi-experimental studies, especially in view of the small number of subjects (15a).

Thus the strategy reflected the view that because of the underlying
Conflicts of educational values there was a need for evaluative involvement in them; 'by serving the academic innovators...by clarifying the processes of education...!' and using methods such as 'semi-participant observation.... to identify the operative social and psychological mechanisms...which engage the interests and efforts of students...!' (14e), and 'providing insights into the difficulties experienced by students as they try to adapt to the demands made on them by....the social situation they encounter in the university' (26b)

In addition, in using survey techniques, especially in the Switch to Science project, I went beyond the data in order to 'relate...to more general problems and ideas' (60) especially in view of the bewildering array of possibilities in work and education faced in schools careers guidance (also 26c).

2.23 Rejection of Transactional Evaluation  'Transactional evaluation is a developing aspect of educational accountability. It looks at the effects of changed programs - in schools and other institutions - on the incumbents of the roles in the systems undergoing change, at changed role relationships and latent apprehensions among those responsible for the educational services - teachers, administrators.... A comparison with traditional summative and formative evaluations shows that the target of evaluation is different... the system, not the client of the services rendered by the system...to transform the conflict energy of change into productive activity; to clarify the roles of those persons involved in the program changes, not to produce new knowledge or ascribe causality.' (61a)

In Stufflebeam's typology, this would fall very clearly into process evaluation (19m). Whilst this is clearly a necessary part of the evaluation of any innovatory activity, and indeed many opportunities arose for it to be considered, I rejected this mode, except where it served the project aims, for example, aim (c) of the first project which involved a study of methods related to student diversity. This was to serve the wider purposes of the sponsor, for which aim (d) was not considered strong enough to justify the lengthy work which would be involved in serving purposes specific to the Institution and not necessarily generalisable. This included refusing to assist a tutor extend and develop tutorial skills. Further, in the second project, the selected course teachers contributed on the whole as a team, so the course organiser could perform his own transactional evaluation.
to utilise the impact of my interventions on teachers in a productive way. Thus in the first project, I made clear my own background and hoped-for involvement in observational and experimental activities. This led all teachers to allow me access to their classrooms, laboratories, and tutorials, but demanded honest feedback to teachers. Such feedback was always anonymous, unless my own views, but I always reserved the right to withhold 'damaging' feedback.

Nevertheless since transactional evaluation involves not only the protagonists and the designers of an innovation, but also a representative sample of persons likely to be affected adversely or disturbed by the consequences of the change (and) as well as attempting to improve the program, will also attempt to analyse the dysfunction of the changing organisation ... due to the threats that change imposes on stable roles (61b). I did seek any such evaluative information and passed it to the course organiser for his action so long as it did not impinge on the illuminative style adopted in the research.

2.24 Other comments on the methodology In a similar way, there was more emphasis on summative evaluation 'for many audiences of a potentially generalisable program' than on formative evaluation 'for a local audience of a program in a specific setting' (66i). However, I considered 'curriculum development' models (16, 32, 48) as inapplicable since the broad objectives had not been interpreted (48). I would have had to commit a substantial amount of time to provide evaluation results based on detailed objectives generated as part of the project especially as they would have been of dubious reliability and generalisability.

Examples of the kinds of objectives which might have been generated are as follows.

**Switch-to-science Project**

The student will be able to:

1. state the basic rules and formulae applicable to a given area of the subject;
2. insert quantities into these formulae and manipulate them to solve simple problems;
3. interpret a problem of standard type; select relevant tactical approaches and formulae; solve that problem.

Further examples of possible objectives are given in Chapter 6.
The broad course goal of preparing participants for the more traditional aspects of a teacher's work might be interpretable in ways such as:

the teacher will be able to:

(1) write on a blackboard so that it is easily readable from any point in any classroom/lecture theatre;

(2) produce a clear overhead projector transparency 'appropriate' to the desired communication.

It should be clear that a full interpretation of even this broad goal requires the subsequent ability to communicate to students: logical subject matter analyses, patterns and structures; ways of thinking and interests. The assessment of such communication would then be required, clearly beyond the scope of a small scale evaluation project. Nevertheless in the second project I made a more definite attempt to evaluate changes against a sample of 'objectives' (see also 26d).

Thus the emphasis in both cases was at a human level. In view of the unusual nature of each group the basic question was *how does such an unusual group fare in the educational and socio-cultural environment of higher education?* with its host of supplementary questions. Whilst this necessitated attending to values of other important figures, e.g. course teachers in respect of support to students changing courses, or senior teachers in respect of teacher education and innovation, the values of the participants themselves were important course outcomes.

Seen from Goodlad's and Stufflebeam's viewpoint, we can say that curriculum development flows from values —> goals —> objectives —> situation design; and evaluation changes flow from context —> input —> process —> product. It is maintained here, however that information for decision making can flow back. Whilst clearly information about the attainment or non-attainment of objectives (product evaluation) will assist design and implementing decisions, it is further contended here that product evaluation can assist in the valuing and weighting of objectives (69). Thus it can 'illuminate' planning decision making by assisting decisions about the kinds of objectives and kinds of effects thought worthwhile.

Similarly, linking process and product evaluations i.e. asking how effects were brought about, and why objectives were not attained, can
for which groups. This is especially true of innovatory courses, where the underlying theory required for structuring decisions about choice of strategies appropriate to objectives may be non-existent or at least too general, and the effects of a course not adequately predictable.

Further, this can assist planning decisions e.g. can we afford this kind of outcome if achievement demands too many resources? Similarly process evaluation can assist structuring decisions e.g. will teachers accept proven methods? Have teachers the necessary skills? If not then, in addition to adapting course design (structuring changes), planning decisions may need to be considered in respect of teacher education. This was the stance adopted in the researches in which information was sought to add to the fund of information relevant to the large decisions about the system as a whole. Thus, the task assumed was to provide a comprehensive understanding of the complex realities surrounding the programmes, by providing a rich source of information of all kinds, to contribute to a broad understanding of the courses, relevant to the many and varied purposes of the varied audiences who would make different types of decisions.

2.3 Methodological problems

This section reviews some of the problems encountered in the research, related to the research setting, the adopted strategy, and associated problems of role, especially in relation to the multiple audience and the choices open in the evaluation. In some instances it prepares the ground for chapter 15 in which the evaluations are themselves evaluated and for chapters 16 and 17 in which proposals are made for the development of future methodologies.

2.31 Problems of Objectives A fundamental problem remains in any evaluation of course outcomes, viz, that it is never easy to put a 'scale' alongside learning. Increments of learning are different in size as concepts vary in complexity; discrimination becomes finer over time and hence learning steps become bigger; different individuals have different needs and difficulties; different individuals may have learned very different items but can be considered to have learned 'adequately' if the item samples can be considered equivalent. That is to say learning can rarely be considered as progressing along a defined path in discrete and equal steps; rather it is more akin to fabricating a multidimensional web, through forming nodes and links between such nodes.

Hence there is an advantage in attempting to specify objectives in
However, specification of objectives must take account of the complexity mentioned above. This led me to concentrate on types of learning problem and samples of aims and to work at a quite general level, to determine the effects of the courses in a fluid and responsive way.

2.32 Problems of values and interventions This may be summed in two questions *Are the underlying assumptions within (the) research (clear) so that it can be evaluated in terms of these foundations?* 'Am I genuinely interested in this problem but free from strong biases?*(15e). The evaluator then, has to be as aware as possible of his own values and attempt to correct for the influence they have on his observations and ultimate judgements, or state the positions he adopts so that those who may be influenced by his reports, clearly understand his position and make their own corrections.

For the first project, I was in favour of school leavers and mature students having a wide choice of Higher Educational opportunities whether vocational or otherwise. I was in favour of science graduates taking up opportunities in the Civil Service, Foreign Office, Government, Management, Administration and so on, more traditionally the province of Arts graduates or non-graduates. I did not view with concern the employment of science graduates in other fields, professional or not, in spite of the greater cost of such education. I wanted to encourage the recruitment of science teachers who had been educated more broadly than traditionally (including Engineering). Similarly I held that a failure of students to learn, and that loss of interest or motivation, is substantially a failure of teachers to adapt to students and their needs.

For the second project I was used to initial training courses for school teachers involving about 1 year's full time equivalent study in the principles and practice of education and related subjects, including for example, the psychology of learning, the history and philosophy of education, as well as the study of specific recent advances in the development of curricula in the student's chosen subject and field. These developments included curricular changes designed to achieve new kinds of objectives for students, particularly in relation to the widening of the social and intellectual base of student populations; the contemporary questioning of values and assumptions; developments in human knowledge and the breaking down of hitherto traditional subject boundaries as a result of these. This meant I had to accept the real situation found in
in specific subject areas and their research aptitudes and skills and being reluctant to accept a need for teacher education, or accepting only short courses.

The above values, whilst inevitably influencing both researches, were withheld as far as possible from transactions with non-XET teachers of the first project and with students of the second, but occasionally affected students of the first. I maintain here that this did not affect the generalisability of the findings, particularly as 'unobtrusive observation' and 'triangulation' techniques were adopted (15d, 18h, 58).

In such interactions in innovatory courses, the presence of an evaluator inevitably influences students, whether by Hawthorne or placebo effects (59d). In both studies, course members had been selected for special attention and were volunteers. I could not make direct observations of the effects of these upon the success of the course, though a few participants of each course made explicit to me, their awareness of the possible benefits of my consulting them ('Guinea pig' effect and 'role selection', (15f)). In this way however, I could focus my attention more sharply on problems of teaching and learning appertaining to each course. However, since courses of this nature should be carefully monitored, due to the vulnerability of students on the one hand, and to the need to ascertain any lasting effects on the other, the presence of an evaluator should be accepted as a normal part of the course design.

Similarly, the enthusiasm of the innovator himself must be expected to exert a 'powerful pedagogical force' (14f). I saw this effect in reverse in the first project, in which his lack of involvement was viewed critically by students as lack of interest - 'rectified' by his involvement, upon my advice. Similarly the integrating effect of the innovator in the second project, through continuity in teaching and social participation was clearly beneficial to student interest, motivation and group cohesion.

The above discussion exposes a value position of mine hitherto not made explicit until the completion of the two separate reports to the two funding bodies. This was my tendency to give priority to students in ways which in certain instances prevented me from being sensitive to other views and from addressing myself to wider issues, because the research involved the students as people. This was because they were being 'operated on' by others, which meant that teachers' perceptions
changes in student understanding and valuing in ways initially unseen or only dimly predictable or even later regretted. It meant that these changes might not necessarily be reconcilable with those of the institution or setting, in which the course participants needed to work later, to lead to student problems of coping with their own changed values and aspirations, not foreseen in the curriculum design.

I found myself more clearly identifying with students, particularly in the first project. This position was recognised both by them and by others involved in the researches. It affected the second project in that I did not consult participants' heads of departments about how they perceived changes brought about by the course and the effects on members of their department. This was mainly because I felt that it would impinge upon my highly valued relationship with participants, without which the research could not have developed.

In respect of interactions with teachers (and students in the second project) it is important to note that whilst originally trained in a physical science and empirical research in that science I had been and am currently involved in teacher education. I was therefore somewhat more aware of educational approaches, especially in the sciences, both at school, college and undergraduate level, than many of them. Therefore in the first project I had to put aside any preconceived notions about what should be the best designs of learning situation, since what was offered in the course was based on the experience of the teachers involved, potentially invalidating my own initial judgement. This also meant that I could not give feedback about undesirable side effects which could be traced to the basic underlying approach of the respective teacher, however kindly and interested. This was in spite of the respect given to my credentials as teacher educator. I abdicated this role in favour of the more neutral approach.

It also required me to maintain a high degree of confidentiality as regards information about personalities and institutional politics that others might be inquisitive to know (18j). Teachers often made attempts to discern the source of student comment and feedback. These were relatively easy to resist, even when correct guesses were made.

In the second project, it required me to be impartial about the teaching efforts of course participants and to be supportive where requested.
involved in the investigations raised important issues about the 
generalisability of the findings in view of the limitations this 
imposed on possibilities of fundamental research. They led me in the 
first case to reject a transactional basis for evaluation, even though 
it might have led to a better development of the curriculum, not from 
a need to keep all variables constant, but through the more important 
need to generalise nationally. Thus I emphasised validity rather than 
reliability, through intensive involvement in addressing real issues, 
assuming that the set of subjects spanned a reasonably representative 
range of students or potential students.

For example, I explored problems of 'pre-knowledge' and methodology 
and their implications for the curriculum. Although conducted on a 
'micro' scale, I believed these explorations to be of fundamental 
significance in relation to recent developments in curriculum thinking. 
Therefore I decided not to further refine the tests and remedial work 
at a point where inescapable and important conclusions emerged, i.e., 
that:

(1) preknowledge surveys are essential in view of student diversity;
(2) they can be devised easily after appropriate subject 
    matter and analyses;
(3) they are easily developed and extended in the light of 
    simple analyses and feedback from students during a course;
(4) they can be matched easily to 'remedial' work which is 
    helpful in easing transition problems;
(5) student motivation is improved greatly through the 
    personalised diagnostic and remedial approach.

Thus, although there is a greater imperative to adopt this tactic in a 
general curriculum with greater student diversity, teachers can with 
little effort improve their teaching with any group. Similarly, the 
use of PERT (65) in a concept analysis confirmed a simple technique useful 
at points in a course causing students difficulty. This is generalisable 
to any courses with prescribed analysable content, but more important 
where there is student diversity.

For both courses there were problems of generalisability related 
to projections from the findings: for the first project, arts students 
selected themselves for a potential science career, making the course 
not necessarily related to sixth form curriculum reform; for the second,
those already educationally more sensitised.

2.34 Problems of role In some respects, I could be seen as an insider wearing an outsider's hat. The extent that this hat was visible to various participants and clients did vary greatly, notwithstanding the relative benefits of 'inside versus outside evaluators' (59e). In particular I resisted being used as an insider, especially when concerned with interpersonal conflicts which threatened the viability of the first project, by severely limiting my freedom of action, choice of issues and methodology. These conflicts derived from suspicion of change, efforts and resistance to change, since the rationale for change is either not understood or apparently threatens institutional survival (14).

In addition the transfer of responsibility for the first year of the course to the IET, led to a lessening of the course organiser's influence on decisions, for example about the suitability of teachers, methods and approaches used, and about the kinds of goals appropriate. This reduction in the autonomy of the course organiser, whose course linked very closely with others, together with his differing strongly with those involved in teaching and organising these courses in some matters especially related to other innovatory work, transferred problems to this research. Thus the evaluation could not be reliable in respect of 'conflicting value positions' nor easily explore 'criteria which might be considered in weighing different decision alternatives' (19q). Nevertheless, sections of the report appropriate to such 'clients' (3iv), clearly communicated relevant information, a point not apparent to other clients.

I was also at various times, asked to act as teacher, administrator, liaison person, selector, personal tutor and sometimes general dogsbody. I resisted these pressures as far as possible, to maintain an appropriate neutrality and independence. These issues should have been brought into open discussion for resolution, and to facilitate the development of the underlying contractual relationships and role agreements. These forces are represented in Figure 6.
Any pair of these forces could be pulling in opposite directions at any one time, occasionally leaving me in 'no-man's-land'. This distinction was easy to maintain in the second project.

As an insider, however, I came to believe in the courses and even presented strong arguments to continue the courses in the face of temporary or permanent closure, 'successful' in one case.

The local context then, complicated the evaluation in ways peculiar to a University. Whilst courses should ideally contribute to the broad context of need, they must necessarily, meet needs of institutional context in order to survive. This is especially true of innovatory or untypical work, carried out in small units competing for scarce resources.

Thus in the first project we have a course operating at a critical level: with minimal student numbers; against some opposition to the course; having a lower success rate and higher transfer rate; having a poorer cost effectiveness compared with 'A' levels; and causing a resource drain on the IET which had its own 'organisation-maintenance imperatives that influence decision making' (70). Maintaining a neutral role under these conditions was often difficult.

2.35 Problems of choice relevant to scale and scope	Illuminative evaluation brings its own problems: to which of the emergent problem areas to give priority; how to make these decisions of a 'substantial' class (19n) in the light of potentially conflicting values. It is clear
nature. Even a research rationale leaves much freedom of choice: in the two projects this involved judgement of what would be of use, relevance or importance (19p) in the short or long term, without real discussion with the primary audience. However, the breadth and range of the explorations of the illuminative approach themselves protect the evaluator to a certain extent by the richness of the final portrayal. In this respect I attempted to present 'the best and worst of program happenings' (66f) though missing some of 'the reasons the evaluation was commissioned' in the first project, viz. the need to provide a detailed 'syllabus matching' analysis.

In the first project, whilst the course organiser and many of the teachers of this and other courses would have preferred in many instances the development of learning materials, I saw the sponsor's needs and the broader needs of the research as permitting only small scale experiments to investigate strategies and tactics of teaching and learning. This involved choices, for example, I chose to perform comparative tests using sixth form science students but not to analyse the tests in terms of the items (33).

In the second project, I chose to measure 'innovation' by course participants. I chose not to interview heads of departments of Institutions whose lecturers attended the course (see 2.33). In this case the real question is 'is the course achieving its objectives?'. They are rather as follows.

- Can the course, short as it is, be expected to achieve deep and lasting effects?
- Are these achievements acceptable in the teachers' departments?
- Is this the right time for such courses?
- How quickly could they develop into more substantial courses?
- What mixture of courses based on sound educational practice is necessary?
- Will the small achievements observed help or hinder in the long term a fundamental reappraisal of current practices?

These were seen to be questions of context to be answered by those more steeped in university practice than myself. However I left the answers to some of these questions implicit in the report.

2.36 Problems of audience The problem of multiple audiences was not resolved in the work presented. For each of the separate audiences to
different decisions. To achieve this communication, a style of reporting was adopted which would allow these audiences to extract what they were prepared to accept as relevant to their purposes.

Thus, for example, the information presented on the national availability of 'switch-to-science' courses, the only such document known to the author, was on the one hand, not apparently relevant to Schools Council, but on the other hand, relevant to many of the other audiences.

Similarly, the second report was designed not to alienate those who would not wish their teachers be too innovative lest their colleagues be upset, but also confirm the limits of such effects for those looking for this kind of evidence.

In this respect the first report was too ambitious in some respects and the second carefully limited to the purposes adjudged 'most relevant to the various groups having an interest in the program' (66g).

2.37 Problems of a lone evaluator In each of these projects, the resources which I as one individual, could or would bring to bear on the multiplicity and complexity of the problems which surfaced during the research was a most important limiting factor in view of my own (limited) capabilities and perceptions of the situations.

Whilst I can derive comfort from the belief 'that there are few "critical" data in any study, just as there are few "critical" components in any learning experience', (66h) my conviction remains that a single evaluator is in a weak position.

Many authorities have stressed the need for a team approach to evaluation (e.g. 34i) e.g. 'a collaborative mode of inquiry - in that expertise from relevant disciplines is brought to bear on the design, conduct and analysis of the inquiry' (20d).

Other, more specific proposals for team membership stress that 'no one person possesses all the skills needed to conduct evaluation work ... planning, quantifying behaviours, data collection and analysis, report writing and small group leadership'. 'The evaluation unit meets at least once a week ... to critique each other's work ... or to bring collective wisdom of the group to bear on particular problems' (62).
unit such as the IET was during its formative years, in which the evaluation skills and insights were in their infancy, though growing rapidly in the time of the latter evaluation. Certainly the staff meetings of the type suggested by Provus were very rare and usually late in a project. Nonetheless, individual relationships and consultations were always strong and supportive, but conducted on an ad hoc basis.

* Since the completion of the projects described here, members of the IET have formed an evaluation group, which meets regularly in the way described.


PHILIPS, CELIA M., Some changes in the factors affecting University Entry (unpublished), 1969.


(4) C.V.C.P., Letter to Vice Chancellors, CIRC/72/20, 10 Mar 1972 (attached).

(5) U.G.C., Letter to Vice Chancellors, 8/15/01, 115/40/05; 29 June 1971.


(7) GREENAWAY, H., Training of University Teachers. SRHE 1969.

(8) UNIVERSITY OF SURREY Training and Development of University Teachers and Administrators: A Research Proposal by the University of Surrey Oct 1971.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Journals/Conference Details</th>
</tr>
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<tbody>
<tr>
<td>BOUD, D. J.</td>
<td>The Laboratory Aims Questionnaire - a New Method for Course Improvement.</td>
<td>Higher Education, 2, 1973, 81-94.</td>
</tr>
<tr>
<td>BOULDING, K. E.</td>
<td>The Image.</td>
<td>Univ. of Michigan, 1956.</td>
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<tr>
<td>TROW, M.</td>
<td>'Methodological problems in the Evaluation of Innovation'.</td>
<td>In Readings in Evaluation Research, Caro, F. G. (ed), N.Y. Russell Sage, 1971. (14a) p. 82; (14b) p. 81; (14c) p. 92; (14d) p. 92; (14e) p. 92; (14f) p. 90.</td>
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</tbody>
</table>
(16) GOODLAD, J. I., with RICHTER, M. N. Jr.,

(16a) p. 5 & 26-27; (16b) p. 5; (16c) p. 5;
(16d) p. 18; (16e) p. 2; (16f) p. 12;
(16g) p. 24; (16h) p. 28; (16i) p. 47.

(17) STAKE, R. E.,

(17a) p. 1; (17b) p. 4; (17c) p. 6;
(17d) p. 6.

(18) PARLETT, M. & HAMILTON, D.,

Evaluation as Illumination: a New Approach to the Study of Innovatory Programs.
(18a) p. 13; (18b) p. 26; (18c) p. 2;
(18d) p. 3 & p. 8ff; (18e) p. 15; (18f) in summary page; (18g) p. 16; (18h) p. 16;
(18i) p. 7; (18j) p. 26; (18k) p. 24.

(19) STUFFLEBEAM, D. L. et al,

Educational Evaluation and Decision Making.
(19a) p. 18; (19b) p. 38; (19c) p. 38;
(19d) p. 96; (19e) pp 218-234; (19f) p. 218;
(19g) p. 90; (19h) p. 42; (19i) p. 88;
(19j) p. 144; (19k) p. 219; (19l) p. 41;
(19m) p. 230; (19n) p. 41; (19p) pp 28-9;
(19q) p. 89.

(20) PACE, C. R.,

Evaluation Perspectives (C.S.E. Report No. 8)
(20a) p. 3; (20b) p. 19; (20c) pp 19-20;
(20d) p. 20.

(21) SKINNER, B. F.,

| (23) | PARLETT, M., | Classroom and Beyond. Education Research Centre, M.I.T., 1967. |
| (24a) | p. 24; (24b) p. 4. |
| (26a) | p. 7; (26b) p. 6; (26c) p. 2; (26d) p. 7 |
| (29) | BLIGH, D., | What's the Use of Lectures? University Teaching Methods Unit (London) 1971 (also Penguin Education). |
(33) CRONBACH, L. J., Course Improvement through Evaluation. Teachers College Record, 64 (1963), pp 672-683.


| (42) ATKIN, J. M., |
| (43) EISNER, E. W., |
| (44) BLOOM, B. S., HASTINGS, J. T. & MADDAUS, G. F., |
| (45) SMITH, B. O., STANLEY, W. O. & SHORES, W. J., |
| (46) TABA, H., |
| (47) GLASS, G. V., |
| (48) TAYLOR, P. A. & MAGUIRE, T., |
| (49) LORTIE, D. C., |
| (50) BRAYBROOKE, D. & LINDBLOM, C. E., |
| (51) SCRIVEN, M., |
| 'Goal-Free Evaluation' in House (ed), op. cit. (27). (51a) p. 327; (51b) p. 326. |
(53a) p. 16; (53b) p. 16; (53c) p. 17.

(54) PARLETT, M., Educational Practice and Research: a note for discussion. 22 April, 1975 (mimeo).


(57) PARLETT, M., Private communication (when visiting the I.E.T. in 1969 after returning from M.I.T.).


(59a) p. 24; (59b) p. 23; (59c) p. 17;
(59d) p. 25; (59e) p. 17.


(61a) pp 3-4; (61b) p. 10.

WYANT, T. G.,

Critical Path Analysis of a Course.

VAUGHAN, B.,


(64) OPEN UNIVERSITY


(65) BECKER, H. S.,

Sociological Work: Method and Substance.

(66) STAKE, R. E.,

mimeo (undated).

(66a) p. 3; (66b) p. 3; (66c) p. 7;
(66d) p. 11; (66e) p. 19; (66f) p. 9;
(66g) p. 10; (66h) p. 10; (66i) p. 6.

(67) SCHOOLS COUNCIL

Science for the Young School Leaver,

(68) MACDONALD, B. & PARLETT, M.,


(69) DYER, H. S.,


(70) WEISS, C. H.,

PART II

SWITCH TO SCIENCE PROJECT

SUMMARY

Part II presents 8 chapters taken from the evaluation report to the Schools Council (60). They are presented in their original form to provide material for the meta-evaluation (61) of chapter 15.

3. The project involved a study of the Science and Engineering courses offered by the University of Surrey for Arts students. They began with Physics B, initiated in 1967, followed by four more such courses. In these, students follow a common first year course, then joined with the 'normal' science entry to their subject. The majority of these students have been successful in making the transition from Arts to Science.

4. All students qualified for the course had been interviewed and expected to give positive evidence of their motivation and interest in science, and of their ability in mathematics. Whilst the major recruit-
ment had followed a late advertisement, which attracted many simply seeking a University place, few students, despite their interest in science, had known of the course before this.

5. In the first year of the course, teaching was largely on conventional lines, though a number of different approaches had been tried in an attempt to provide means for the students to acquire, in a condensed course, the large amount of knowledge and skill required as a basis for success in later stages.

6. Students have, on the whole, not performed so well as their science colleagues in examinations in subsequent years; this, and discussion with students highlighted motivation and learning difficulties which were at least partly surmounted by changes in the first year course and in the guidance given to students.
10. Whilst the first year of the course was achieving a degree of success in preparing arts students for Science and Technology degrees, it would as such not transfer to the schools, in view of the different conditions and needs. However, the content of the course, which was very similar to that of corresponding courses in other universities, did indicate a reduced science content which would be acceptable to University departments of Science and Technology. This is clearly very relevant to the design of broader sixth form courses. Finally, the closure of the Surrey courses in 1973 on the grounds of inadequate applications, reflected external pressures and lack of awareness of this important addition to the range of educational opportunities at degree level.
"The country is short of scientists and the universities are short of places for Arts students. There may be students in Arts 6th forms at the moment who now wish they had opted for science. To help with these problems the Department of Physics is offering to students from Arts and Arts/Science 6th forms who have not taken A-level physics, a four year honours course in physics with opportunities in the second year to change to honours courses in physical sciences, chemistry, metallurgy and electrical engineering. Entrance qualifications are G.C.E. in five subjects of which at least two must be at A-level and include pure mathematics or pure- and applied- mathematics."

This was one advertisement which attracted eight students to the University of Surrey in 1967 to the new "switch to science" course offered in the Physics Department.

An important motive in initiating this course was to provide an opportunity for girls who for various reasons might have been unable to do science in the 6th form or even earlier in spite of their interest. "Girls frequently suffer at school from shortage of science teachers and indifferent laboratory and workshop equipment. Some are even warned against science as unsuitable or difficult" (Times Woman's Page 11.9.67). In December 1966, two months after a previous advertisement, when no applicants had emerged, the Head of the Physics Department (then Professor Elton), in the Evening Standard, is quoted as saying "I imagined the response would
be better. There are, I am certain, a large number of girls in the sixth form prevented from doing science, although they might have wished to do it. They are put off by teachers who claim it is too difficult for girls. A major propaganda effort on our part and that of industry is clearly needed."

In 1966, in discussing the proposed Physics B course he said, "We wish, by means of this, to mitigate the evils of early specialisation in schools, and we are convinced that such a course is possible and in fact will be very challenging."

He also said in a letter to the Times Educational Supplement, "We in this College (then the Battersea College of Technology) believe that an A-level pass in mathematics and two arts subjects is a very acceptable mixture indeed and one that does much to counteract premature specialisation. It is particularly suitable for the honours course in Human and Physical Sciences which we have been offering for some years and as from 1967 we will accept students with this entrance qualification\textsuperscript{†} into a four year honours course in Physics..... In this way we hope to be able to help those whose interests in science may have been late in developing or who for one reason or another were unable to take science subjects in the sixth form."

Since 1967 45 men and 25 women\textsuperscript{*} (average age 20\textfrac{1}{2} years)\textsuperscript{*} have embarked on this course. It has therefore achieved the objective of attracting women students, significantly increasing their number in the departments of the scheme at least during the first four years of the course. (Table 1)

\textsuperscript{†} The requirement of an advanced level pass in mathematics was relaxed to one of a good ordinary level pass.

\textsuperscript{*} plus two occasional students.
Table 1

Women students entering the second year

<table>
<thead>
<tr>
<th></th>
<th>Physics</th>
<th>Metallurgy</th>
<th>Physical Sciences</th>
<th>Other (Maths, HS or HPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B  All</td>
<td>B  All</td>
<td>B  All</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>3  6</td>
<td>0  2  1</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1969</td>
<td>4* 14</td>
<td>0  2 (2)  4</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1970</td>
<td>3  4</td>
<td>1  2  4</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1971</td>
<td>0  4</td>
<td>1  6  3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1972</td>
<td>0  4</td>
<td>0  4  3</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

* two of these transferred to Physical Sciences during the second year.

The course was designed on the assumption that after an Introductory Year in which essential elements of mathematics, physics and chemistry would be studied, the students would join with the "normal" entry of students to the Physics Department. It therefore does not attempt to produce students capable of passing advanced level examinations, but students capable of profiting from a particular university science course.

The structure of the course is shown in Table 2.

The first two terms† of the Physics A degree course and also of the Electrical Engineering, Metallurgy and Physical Sciences Courses (PEMS) was a common course consisting of 15 separate parts, each department's students doing 11 of these. Although each student enrols into one of the four departments at the beginning of his first year, at the end of the PEMS course (originally so called because of the initial letters of the departments concerned, now standing for a "Preliminary Course in Engineering, Mathematics and Science") can transfer to any one of the other three departments. No barriers are put in the way of such students though in fact very few students from the normal 'Science entry' do transfer.

† In 1971 this common course was reduced to a length of 1 term.
Table 2

The B Courses†; the Introductory Science Year in relation to other parts of the course

<table>
<thead>
<tr>
<th>First year</th>
<th>Second year Stage 1</th>
<th>Second year Stage 2</th>
<th>Second year Stage 3</th>
</tr>
</thead>
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<tr>
<td>Intro. Sc. yr.</td>
<td>CABBS</td>
<td>Biochemistry</td>
<td></td>
</tr>
<tr>
<td>Biochem. B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics B</td>
<td>P</td>
<td>Physics</td>
<td></td>
</tr>
<tr>
<td>Elec. Eng. B</td>
<td>E</td>
<td>Electrical Eng</td>
<td></td>
</tr>
<tr>
<td>Metall. B</td>
<td>M</td>
<td>Metallurgy</td>
<td></td>
</tr>
<tr>
<td>Ph. Sc. B</td>
<td>S</td>
<td>Physical Sciences</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mathematics, (Engineering, Tonmeister)

**KEY**
- Compulsory Industrial year
- Optional Industrial year
- Arts A levels
- Science A levels, ONC etc.

Students are accepted into a specific department but may change department with in common course schemes.

† B refers to the whole course, not simply the first year.
This possibility of transfer led to three of the 1968 Physics B and six of the 1969 Physics B students joining the Metallurgy or Physical Sciences courses. This was one of the considerations which led to the institution of four separate B courses with the same entrance requirements, viz:

- Physics B
- Electrical Engineering B
- Metallurgy B
- Physical Sciences B

the new courses officially starting in 1971 to coincide with a revised one-term PEMS course and a fifth B course, Biochemistry B.

The progress of the 61 students accepted so far is indicated in Table 3.

From this table it can be seen that, 'even though as yet there are only nine graduates of the scheme, the majority of those students entering the course, successfully make the transition from arts to sciences. The course therefore is successful in achieving one objective - showing that students who chose arts subjects in sixth forms can tackle science and mathematics at a sufficient standard to be comparable with those who have studied sciences more consistently and for a longer period.

Though a fuller analysis of the success of the course will be provided in later chapters this assessment will not be complete without noting that at the end of their first year 20 students out of the 61 so far have not gone onto their second year in subjects in the scheme at least immediately.
<table>
<thead>
<tr>
<th>Year of course</th>
<th>FIRST</th>
<th>SECOND</th>
<th>THIRD</th>
<th>FOURTH</th>
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<tr>
<td>Student group, 1 = 1967 etc</td>
<td>1 2 3 4 5 (6)</td>
<td>1 2 3 4 (5)</td>
<td>1 2 3 (4)</td>
<td>1 2 (3)</td>
</tr>
<tr>
<td><strong>New entry into course</strong></td>
<td>8 16 14 15 8 (9)</td>
<td>1 2 3 4</td>
<td>5 11 12 8 (8)</td>
<td>6 11 12</td>
</tr>
<tr>
<td><strong>Re-entry into course</strong></td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Successful and continuing (or completed)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful re-examinees</td>
<td>1 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(temporary)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(permanent)</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Transfers</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other science</td>
<td>2 3 2 2 1</td>
<td>10</td>
<td>1 1</td>
<td>1</td>
</tr>
<tr>
<td>Non-science</td>
<td>(1)</td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial year</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fail</td>
<td>0 2 (1) 3 0</td>
<td>4</td>
<td>0 2 0 1 3</td>
<td>0 1 1 2</td>
</tr>
<tr>
<td>% success - excluding transfer to other science</td>
<td>72%</td>
<td></td>
<td>83%</td>
<td></td>
</tr>
<tr>
<td>% success - including transfer to other science</td>
<td>89%</td>
<td></td>
<td>86%</td>
<td></td>
</tr>
</tbody>
</table>

* net totals balance together
* including one student returning after 1 year's absence
* including 1 who failed exams
+ one student withdrew just before exams, returning 1 year later, now transferred to "other courses".

() figures for 1973 as they are known

× up to 1973 but excluding 1972-73 figures
Of these, one repeated the first year studies (and has continued quite successfully so far) another two sat or resat examinations the subsequent year successfully, and at least ten elected to study other courses, either at Surrey (4) (Human and Physical Sciences) or elsewhere (6) in Science based subjects not offered by Surrey. One of these the following year received an Exhibition for being the best student in his first year of a Geology course, subsequently receiving first class honours and accepting a lectureship in the department.

The observation that the first year, as expected, proves so far to be the greatest hurdle for the course, must therefore be modified by the knowledge that many of the students who fail or withdraw, successfully continue their studies in Science subjects, or in one known case (additional to that noted above) actually works as a scientist.
4.1 Selection

Students are admitted into their chosen department from the beginning of their course, after an interview conducted by a representative of the students' chosen department and by Professor Elton, the originator and administrator of the course. The selection process is designed to pick out those students whose choice of subjects (because of the complexity of such factors as current interests, teacher advice, school facilities, teacher appeal, restriction of allowed subject combinations) can be said to have been the wrong one, from those whose main interest is to obtain a University place.

The majority of applications from "Arts" students result from the advertisement placed in the national press just after the time when 'A' level results become known. This can be seen as making it possible for those Arts students who failed to get a University place to consider the possibility seriously, perhaps for the first time, that they might be able to attempt a science or technology degree. A proportional number of applications are received during the year, the majority of these being through U.C.C.A. from students studying science subjects at 'A' level who have clearly misunderstood the purpose of the course, and are therefore ineligible for consideration. Those making a formal application, who satisfy the matriculation requirements of the University, whose studies have been predominantly in the Arts or Social Sciences, are almost invariably called for interview.

The principal purpose of the interviews is to establish students' motives, both for their original choice of non-science subjects and for their wish to change to science, but which is also to assess their likelihood of success, particularly in view of the large mathematical content of the courses.
## Student 'A' levels by Subject

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<td></td>
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<td>Physics</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>1†</td>
<td>0</td>
</tr>
<tr>
<td>Chemistry</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2†</td>
<td>0</td>
</tr>
<tr>
<td>Geology</td>
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<td>0</td>
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<td>1</td>
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<td><strong>Languages</strong></td>
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<tr>
<td>French</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>4</td>
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<td><strong>Other Arts</strong></td>
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<td>6</td>
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</table>

† 1 student ex-medicine paying for himself.
### Table 3a

**Student 'A' levels by grade**

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<td>B</td>
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<tr>
<td>C</td>
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<td>10</td>
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<td>3</td>
</tr>
<tr>
<td>D</td>
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<td><strong>Number with 'A' levels</strong></td>
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### Table 5b

**Student 'A' levels by aggregate (E = 1 etc)**

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### Table 6

**Age distribution of students at entry.**

<table>
<thead>
<tr>
<th>Age at entry (to nearest year)</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of students</td>
<td>17</td>
<td>16</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

† Some students are accepted with equivalent qualifications.
In answering questions about their motivation, students are always expected to give positive evidence of their interest in science, i.e. of activities carried out which show that their interest is active and not merely superficial or inspired by the need to "pass" the interview. Students are thus expected to name books and comment on them; to make a few points about a chosen topic; to prove they had made reasonable efforts to develop their stated interests by using any suitable opportunity or by initiating appropriate activities.

Thus a student with a stated interest in astronomy would be expected to use any available telescope from time to time or at least read standard books on the subject. An interest in car maintenance would be evidenced by actual work on cars and knowledge of the workings of some part of a motor car system. Students have been interviewed who started or were active in astronomical societies, who made a telescope, who had small chemistry laboratories in their gardens, who rebuilt a car. Other students became interested in science after they left school generally through their work (e.g. medical engineering sales, work with computers, telecommunications) at the same time often realising that qualifications in science led to improved career prospects. This motivation, whether short term or long term is judged to be such an important factor contributing to students' future success that it is the principal criterion against which selection is made.

Involved in the question of motivation is the choice each student made of 'O' and 'A' level subjects, here school facilities, attitudes of teachers to student choice of science, passing interests, are all considered relevant. Thus students are expected to give reasons for not choosing science at 'A' level, and where no science subject was offered at 'O' level, at that stage too. In the schools of some applicants science was not offered as an 'A' level subject, other schools discouraged a mixed choice of 'A' levels. One student, with interests in Physics, when pressed to choose physics with pure and applied mathematics, rebelled and chose another subject. Others studied one or more science or mathematics 'A' levels.
after leaving school - such students were always given a sympathetic hearing for two reasons; firstly, motivation was already established by their choice and greater maturity and secondly, they often had to study under difficult conditions.

Since mathematical ability plays such an important part in the success in physics and other science and technology subjects, mathematics was originally required at 'A' level. Since few applicants met this condition, this was reduced to 'O' level, thus being the only specific qualification required for the course. This ability has always been probed in the interview: the mathematical history of the students, the extent of any mathematics in the sixth form and their approach to a specific problem presented in the interview. This problem is the rearrangement of the formula

\[ T = 2\pi \sqrt{\frac{L}{g}} \]

to the form

\[ L = \frac{gT^2}{4\pi^2} \]

Unsuccessful students are considered more carefully, and if accepted for the course are advised to do some revision in elementary algebra.

4.2 Student comment on motivation and selection.

It is very clear from students' own remarks that many were only able to consider the possibility of following a science or technology degree course when they knew they had failed to gain a University place and when they saw the advertisement in the National Press. Prior to that, these particular students had not seriously considered the possibility nor did they know that there were courses of the kind offered by Surrey in existence. Other confirmation exists in the response to other occasional advertisements. One student had already decided to do an ONC in a technical college after becoming really interested in science as an apprentice on an engineering shop floor; the advertisement created a new
Students have, however, made enquiries to ascertain the possibility and one such found out from C.R.A.C., at whose office he was able to learn that "Surrey were doing some research into this field"; others learned of the course from Youth Employment Officers.

That many of the students have been frank in saying "there was no University place for me in the Arts", does not imply that this course is only attracting second-class students, on the contrary, many of these students are finding themselves successful, some taking up again an old interest, so that it can be said that for them the advertisement came at the right time. It provided essential conditions for them to consider a change of direction in their studies, whilst they were standing aside out of the main current of the 'system' which, in most instances, carries students inexorably along preventing them from thinking independently. It provides a time to take stock and reconsider their choice when they have not been sure what was right. Failure to make a University place in the Arts in this case does not necessarily mean inadequate intellectual powers but has meant for some merely a wrong choice. Their intellectual powers are proven when they are successful in making up adequate ground in one year to fit in with students with greater experience, not only in new subjects, but in a new field. Others, (Tables 5a, b) would certainly have been acceptable in arts, social science and language courses, some have even turned down places offered them in these subjects.

Students have said that they chose the wrong subjects, making decisions at about fourteen years of age. One described dynamic arts teaching, dull science teaching, appalling mathematics teaching, leading to a "contempt for scientists". Another student, whose school did not offer science left school before completing 'A' level studies, "hating" them. The advertisement, after technical college and some years in work, came as "a bolt out of the blue". Another student, "fed up with sixth form" at school did not want University, turned down a provisional offer, achieved one 'A' level. Rather later,
entered the course bringing to it a mature and lively mind. Another, wanting science, was directed into languages (achieving high enough grades for University entrance) then achieved passes in two science subjects in a technical college in one year. (Without mathematics, this student was not qualified to enter Surrey on the Physics A course.). Another student, starting out on the science side (Chemistry, Biology at Grade A and Geology) having failed Physics 'O' level, took three further 'A' levels (Economics, Accounting - at Grade A - and General studies) and an HND in Business Studies before embarking on Physics B. Another student, the only one in a stream opting for Chemistry at 'O' level, was not allowed to offer the subject as one of ten; later when selecting Botany, Zoology and Mathematics at 'A' level, was put off by the Head Teacher and selected arts subjects.

Time-table clashes have often been given as reasons why Mathematics or Science has not been studied at 'A' level. One student, wanting to do Mathematics, Physics and a modern European Language, found that Physics clashed with the language. Interest in Science, through a fascination for computer technology and space flight, was sufficient to lead to a changed mind about continuing the language study, and acceptance on a College Computer course. On seeing the advertisement, the student saw a better chance of learning about computers. Another, wishing to do Chemistry, Geology and arts subjects, found time-table difficulties regarding Chemistry and no Geology teacher at that time, thus opted for a second language and General Studies. This student decided that the course would provide an opportunity to obtain science qualifications after a mistaken choice in the Sixth Form, and provide a sounder education - "since a science student can read books and educate himself in the arts, but an arts person cannot pick up science so easily ....". Another, who wanted to do Mathematics, Physics and Chemistry after a year as a technician (left school at 16) could not get a grant for this (had earlier done Physics with Chemistry at 'O' level rather than the separate subjects due to time-table considerations) and studied arts.
Science teacher.

Changed minds, a deepening interest in Science, awareness of improved career opportunities in the Sciences, a wish to go to University, a wish to make autonomous decisions about the future, have been other reasons for applying to Surrey. One student "was always well divided between Arts and Science and fell the wrong way - it gave me a chance to put this right .... it fitted what I needed to get on in the field that interested me". This student was well informed about opportunities for transferring from Arts to Science by a Careers Teacher who attended C.R.A.C. Conferences. Considering that "the Surrey course worked by far the best as it was not a course for Science 'A' level 'scrapes', but for Arts people .... I accepted immediately and withdrew from (job interview in chosen field) and the other Universities" who were already very interested in him. This student voluntarily returned to school for a short time to do some Mathematics and study for Chemistry '0' level. Another student, wishing to do Chemistry with Arts subjects found time-table complications and was advised against the combination. At this time, interest in Science lapsed apart from a few technical vacation jobs; however, after a second attempt at Arts 'A' levels in a College of Further Education, he became "very dissatisfied with all the vocational openings for which Arts 'A' levels would qualify, e.g. banking, law". The course gave an opportunity to follow the student's "own course of action rather than that dictated by school, or father", and follow his "inclination to take up Science again, an inclination which had been thwarted by school circumstances a catastrophic, ineffective Physics tuition" and "enthusiasm with Mathematics killed by New Mathematics (SMP)". Another, in work for several years with an established career, decided to study Science at University aiming for a career in research, and found from prospectives that the Surrey course appeared to be the only one available in the S.E., and that "its intentions were to cater for someone like myself".

There are, of course, those who have "a vision of University fixed in their minds so powerfully, that they cannot
or do not want to think of anything else to do. For them, it is a question of getting into University at any cost, on any course." This could apply to students on virtually any University course, though this particular course must present itself as such an opportunity to many students. This is clearly demonstrated by the large number of ineligible science students applying for the course. That the statement above can be made is evidence, at least in the opinion of one student, that the selection system is fallible in this respect. However, no selection panel can claim to be completely successful.

4.3 Background, influences and career choices.

Other characteristics of the students are taken from a questionnaire to which 5/6 of the students from the 1969 and 1970 entries responded. Of these, half (52%) had come from Grammar School, the remainder, approximately equally, from Public School, work or Technical College. Half (52%) had decided to try to get to University at the 'A' level stage, a quarter (24%) earlier, the rest later. Half (48%) felt they had made an autonomous decision in this, but a quarter were most influenced by parents, another overlapping quarter by teachers, not careers teachers. In deciding to go to University, half (52%), were not at all influenced by the suggestion that "its the natural next step after School/Tech., only 8% were influenced strongly. That "a degree will qualify you for a better job" was an influence for the vast majority, strongly for 40%, to some extent for 44%; a lesser influence being the need for "more specialised knowledge for a career you have in mind", over a third (36%) being influenced strongly and a sixth (16%) to some extent. The strongest influence was that "University helps broaden your attitude" a half (52%) being influenced strongly, and 40% to some extent. A fifth (20%) gave additional influences, furtherance of education and a desire to learn more being dominant.

Though advice was derived from a variety of sources,
a large minority (44%) felt that no-one had given advice in choosing which Universities to apply for, a quarter (24%) deriving advice from parents or relatives. During the last year at school, in deciding to switch to science, the majority (60%) felt no-one had influenced them, but a quarter (24%) were influenced by parents. Half (50%) had no idea what decision they would make about their career but a quarter (28%) had. This position became slightly firmer by the end of the first year, the proportion who had decided increasing to 36% and the proportion who still had no idea decreasing to 40%. At this stage, a strong preference for a research career was indicated (half (52%) putting it first or second), followed by lecturing or teaching (36%) followed by design (20%) or testing (16%).

Whilst noting that the object of vocational guidance is to help people come to a decision themselves, other evidence suggests that these large proportions did not discern any particular influence other than e.g. "the general climate of opinion" and their own inclinations.
5.1 The Introductory Science Year

The structure of the course outlined in the first chapter is such that in their second year the students join those entering the University with Science 'A' levels or other qualifications in Science subjects. Thus, the purpose of the first year has always been quite specific. Its major aim is to provide students with an adequate background of knowledge and understanding in Science and Mathematical skills, so that in their second and subsequent years they would not be at a disadvantage, that is, their difficulties would not be any greater than those of students more experienced in Science and Mathematics.

Accordingly, in 1967, the Mathematics and Chemical Physics Departments agreed to provide courses for the Physics Department in Mathematics and Chemistry, respectively, whilst the Physics Department provided its own course in Physics for its Introductory Science Year.

Teaching syllabuses (Appendix 1) were designed by those lecturers who had agreed to take the courses, after a careful study of the PEMS courses (and later courses where appropriate) and consultation with staff of the Physics Department. It should be noted that as this was a part of a Physics degree course and it was that department which provided the Physics course, the lecturing, practical sessions and tutorials were treated separately, whereas the service courses in Mathematics and Chemistry were provided entirely by the respective lecturers.

The first year was also run in conjunction with that part of the first year of the Human and Physical Sciences course for "Arts" entry to the course. As a result, the Mathematics and Chemistry courses for the two groups were identical, though by reason of the University move from Battersea to Guildford, which split the University for two years, this has not necessarily
provide more individualised teaching, the Mathematics Department provided two separate courses, so that at the present moment, only the Chemistry lecture course is common to the two groups.

The time allocation for the separate parts of the course is shown in Table 7. It should be noted that the part played in the course by the Institute for Educational Technology (I.E.T.) has grown steadily from a few additional periods in a year, until in 1970-71 it was providing about one fifth of the teaching (not including practical work). (In that year, when the I.E.T., which had been started by Professor Elton while he was Head of the Physics Department, became an independent unit with Professor Elton as its Head, the organisation and administration of the Introductory Science Course was transferred to it). In 1972, this proportion increased to 35% overall.

The treatment given to the subjects of the first year has differed substantially from the treatment of similar subjects at 'A' level in school, principally in that the lecture method has been widely used, and that the students have been left to organise their own study and devise their own study strategies with little supervision, a practice common to most undergraduate courses. Since the time the Institute began administering the course, building on the experience of the early years, a number of different approaches to some of the subjects have been tried in the search for materials and treatments which might meet more closely the needs and capabilities of the students. Thus, innovation in the courses has been increasing steadily since its inception, as has the amount of guidance and supervision.

Although the lecture has predominated, not only over the course as a whole, but in each separate course, there are striking differences in the approaches to each separate subject. These reflect the original purposes of the courses, the different viewpoints of each lecturer as to the nature of his own course and their personal styles.
Approximate time (in hours) spent in each subject annually (1 year ~ 28 weeks).

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>LECTURES</th>
<th>TUTORIALS/EXAMPLE CLASSES</th>
<th>PRACTICALS</th>
<th>YEAR</th>
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<tr>
<td></td>
<td>-</td>
<td>51</td>
<td>45††</td>
<td>1972</td>
</tr>
</tbody>
</table>

x 50 mins. or 1 hour 50 mins. sessions.

xx 2 hour 50 mins. sessions.

† including 48 hrs. lecture-discussion-demonstration.

†† self-teaching, mainly practical.

* approximate division into exposition-example class.

** including Keller plan sessions time-tabled for tests/consultation.
5.21 Lectures and Tutorials in Mathematics. These use the classical method of the statement of a principle by the tutor, followed by students' application of the principle to problems, probably used by the majority of Mathematics teachers in schools, colleges and universities. A principle may, for instance, be developed by generalisations from examples then applied to new examples of an increasingly complex nature, the students often being involved in the development. This kind of development often takes fifty minutes or so and the natural break is followed by a period of supervised problem solving, in which students progress from simple applications of the principle or rule to much more complex problem solving activities. The lecturer used the period to help students with these exercises, restating the principle, redeveloping the arguments, or correcting the errors as required by the students. As important, he monitors the progress of the class in grasping the new principles and concepts, thus enabling himself to close the tutorial with a presentation of major difficulties and their solutions in a summary of the main work and allowing him to vary the pace of his course as appropriate to the needs of the students. The tutorial is therefore a carefully integrated part of the course and cannot be considered in isolation from it.

Coursework is set weekly, being a number of examples taken from the same duplicated sheets of problems used in the tutorial sessions.

The majority of the things taught in the Mathematics course are of immediate and direct relevance to the subsequent courses of the students in Physics, Electrical Engineering and Physical Sciences in so far as they are required as 'skills' possessed by students for problem solving, or such understandings as are required to follow arguments or to form the basis for the development of new understandings or skills. The remainder are considered to be beneficial in contributing to the students' overall perception and understanding of mathematics.
themselves weak in Mathematics, who attend individually about once per week on a voluntary basis. Students bring current problems which are explored in order to bring to light the basic weaknesses which often trace back to skills tested in the preknowledge survey.

5.23 Keller plan in Mathematics A course in Calculus was given for the first time in 1971 according to the 'Keller plan' 5. In this, students study the course in a sequence of Units at their own pace, proceeding to a subsequent Unit only after being successful in the Unit test. The students study the Unit where they please, but have the opportunity to do so in the presence of a postgraduate tutor who is available in case of difficulty, but who also approaches students if he perceives difficulty. During these time-tabled periods, students are expected to take Unit tests which are immediately marked and any questions answered incorrectly are discussed individually with the students. If such discussions show that a student has not mastered the 'objectives' of the Unit, he, or she, is required to take all or parts of an equivalent test after revising parts of the Unit.

The earlier Units are based on a programmed text, and the later, on a standard text 6. Each Unit covers an appropriate number of sections of the text, and contains supplementary notes and exercises. In addition, a pre-knowledge survey in Mathematics and subsequent directed revision, forms a 'Unit 0' (discussed in Chapter 6 'Other Experimental Work'). Stimulus lectures and films are also given from time to time in the plan.

Although the course is self-paced, a weekly progress chart indicates the minimum rate at which a student is expected to cover the course, which is intended to regulate the pacing and to enable students to achieve a minimum of 18 Units in the academic year. Unlike some other known Keller plan courses, no real practical upper limit is placed on this rate through administration difficulties, as students would normally hold the material of two course Units. They have also been known to take three Unit tests at one sitting.
5.3 Physics

5.3.1 Lectures in Physics. This course has normally been taken two topics at a time to provide variety for students and a longer time for new ideas to develop in students' minds. Thus in a typical year kinematics and Dynamics (three periods per week) and Optics (two periods per week) occupy the first seven or so weeks; this gives way to Electricity and Magnetism, the largest part of the course, which continues for another thirteen weeks in parallel with heat and temperature (3 weeks) wave motion and light (7 weeks) and properties of materials. The final term contains molecular structure of gases and liquids and electromagnetic spectrum.

Each lecture normally begins with a review of previous work and a thorough and detailed development of new work, concluded by a summary. The course itself is notable for its very carefully analysed logical order in the development of the concepts and principles of elementary physics.

The content of the course is firmly based on such physics as is required for all the subsequent courses of the students and has been developed through feedback from physics tutors of current problems both of Physics B and Physics A students, particularly in the PEMS course.

It is interesting to note that the approach to the course is precisely that which has led to the development of new approaches to the teaching of physics. Thus the systematic and formal approach, which rejects live and filmed demonstrations as being unnecessary for students with a completely separate practical course, is designed for highly motivated, able students, who need to learn in a short time a large number of concepts and who are mature enough to supplement lecture work by their own reading.

The lecturer is careful to present to the students such misunderstandings as students have had, qualifications to
He consistently brings in a historical approach particularly when introducing a new principle, attempting to give students an insight into the problems of the original experimenters.

As in the Mathematics lectures, the students are given full blackboard notes and adequate time to take them.

5.32 Practical work in physics  This work has been conducted in the Physics department when a suitable laboratory has been free of the large numbers of students following the PEMS course, i.e. in one or both of the spring and summer terms. Between eight and seventeen afternoon sessions have been made available to each student for experiments which are short enough to be completed in one session by most students. Experiments have varied from simple introductions to measurements requiring the use of standard, basic laboratory instruments such as balances, micrometers, stopclocks, to more difficult exercises involving the use of more complex instruments such as a commercial potentiometer. In the first three years, students were given verbal instructions for each experiment before starting them and consulted the tutor from time to time as necessary. For example, they might have been asked to design a heating coil to a certain power rating, or determine the characteristics of a p - n junction or measure the resistance of copper wire over a wide range of temperature. In planning these experiments students were expected to gain an insight into methods of experimentation. In the fourth year, 1970-71, when students were expected to attend all fourteen or so sessions rather than attending alternate weeks, many of the experiments were prepared with written instructions adopted after the experience of some experimental practical work of the project (reported in "EXPERIMENTAL LEARNING MATERIALS").

In the development of this course, scripts were provided for all the experiments, and students were expected to keep a notebook for all the experiments. In addition, a suitable course was selected for each student in an adaptation to their needs, experience and ability.
6.34 Demonstrations and discussions (Physics) In response to the need for students to acquire a closer experience of new concepts and principles, demonstration classes were initiated. As students were encouraged not only to see, but also to use their sense of touch where appropriate, these were known as "tactile tutorials". They were accompanied by discussion, often lengthy, arising from questions designed to make students think and conducted by a schoolteacher fellow, now a lecturer in the I.E.T. This was designed to help students to supplement the theoretical view and acquire a physical picture of things taught. There was careful integration with the lecture course achieved through regular consultation and careful preparation within the limitations of the availability of apparatus. In these tutorials there was also a deliberate attempt to provide a different viewpoint. These demonstrations have been developed as self-teaching practicals and related work, integrated into the Electricity part of the course.

5.34 Programmed Course in Electricity This course began in 1970, when the possibility arose for the lecturer in the Institute for Educational Technology to take a more substantial part in the Physics course.

This work stemmed from the need to explore methods of improving students learning in certain specific areas. At this stage, it was clear that the nature of the subject made it difficult to learn, involving a high degree of abstraction and a large number of interlinking concepts and principles, which involved theoretical aspects remote from students' everyday experience leading to quite general difficulties amongst the students. Therefore a course which utilised extensive demonstrations in which the student played an active part was designed. Like the Keller plan in Calculus, the course is based on a programmed text, Programmed Physics (Electricity and Magnetism) by Joseph & Leahy, supplemented by extensive references to selected standard texts which became less directed as the course progressed.
In contrast, the 'units' i.e. chapters, are considerably longer, and the end of chapter tests are taken at much less frequent intervals. These tests, which are taken by the students under pseudonyms, are marked immediately, the published results giving feedback to the students about their progress relative to the rest of the class and to the tutor about the progress of the class.

Students are expected to work through the program independently, though allowed to use alternative texts provided they could solve the end of chapter problems and understand the associated review section. In addition, duplicated notes are provided, in an attempt to give a broad overall view of the subject, to give students reference material, and to form a basis for discussion. Students are expected to read designated sections of the chapters before the discussion class, which covers student problems with the text and end of chapter problems, the progress tests, and demonstrations of appropriate phenomena.

Students are given details of the course aims and objectives and a complete list of terms derived from an analysis of the courses in Electricity given in the following year of the course. This list is seen as a vocabulary of the technical language of communication in Electricity used in these later courses.

5.35 Example classes in Physics Postgraduate students, one of whom had taught in a school, conducted classes in which examples were done or discussed - these could be end-of-chapter problems, examination questions, or tutorial sheet problems set by the postgraduate which were handed in either optionally (1967-9) or compulsorily (1970-). This compulsory tutorial work arose from erratic attendance in parts of the course and the need to provide a means to ensure that a minimum steady amount of work was being done. The tutor normally would keep in close touch with the lecturer and be aware of current lecture content, approach and likely problems. This consultation varied from tutor to tutor. In the first term of 1970, students
determined by the preknowledge survey (discussed later) for one of their two tutorials. This scheme was continued to provide a tutorial to match the needs of the students.

5.4 Chemistry

5.41 Lectures in Chemistry  Initially, principally because the course was a Physics degree, and later because the common 2 term course (PEMS) was predominantly Physics and Mathematics, Physics and Mathematics have been treated as basic courses, the one to provide predominantly basic knowledge and understanding, the other to provide basic skills. In contrast, Chemistry has been treated as a subject designed to give students a broader picture of Science, and assumed no extrinsic motivation.

This course is a highly concentrated survey of general chemistry, covering a similar amount of ground to the physics course in a rather shorter time. In intention it is modern in outlook and order of syllabus, highly stimulating, presenting a considerable amount of information in each lecture and having as its main aim that of encouraging the students to read widely, especially to improve their general knowledge. In addition, specific books are recommended, many of these being provided in the library, several copies of each being available; others, mainly paperback, being recommended for purchase. These latter are attractive, modern and cheap, in some cases being so general that they can be considered to supplement the physics course.

The lecturer draws from his own research experience and that of his colleagues to give relevance to his course and stimulate students' interest.

In 1970, and subsequent years, a lecturer from the Chemistry department provided the organic chemistry part of the course in the third term.
methods of Chemistry conducted in the final term for which student attended weekly. They conduct about seven experiments based on detailed practical notes, the whole class performing the same experiment.

5.43 Tutorials in Chemistry These were tried in 1969-70 principally for H.P.S. students but also for the Physics B students. A variety of approaches was attempted using models; slides; films; programmed texts, both published and trial; each with discussion. Tutorials were continued in 1970-71 at the request of the new students but discontinued after a few weeks. In 1971-72 and 1972 these were revived with the main aim of generating in an actively responding group a perspective in the subject rather than as a supplement to the lecture course, by examining areas in Chemistry, e.g. shapes of molecules. This did not preclude discussion of general difficulties.

5.5 Other work

5.51 General tutorials These were initially a development of the "tactile tutorials" in which demonstrations were conducted from time to time, a selection of films were shown, some research tests and self-tests given, and some experimental teaching work carried out, particularly with film loops. Also arising out of student needs, expressed both by staff and students, a second principal purpose was, however, to promote discussion over a wide field, either student initiated, or stimulated by short talks, to broaden students' appreciation, to integrate different aspects of the course, to extend their awareness of Science and to provide an opportunity to exchange and develop attitudes to Science.

The specific teaching function of the tutorials, after difficulties were found by the postgraduate tutor stemming from his own lack of experience in teaching and lack of material resources leading to excessive time being required to prepare demonstrations, was taken over by an experienced teacher.

In these tutorials, in which the prime emphasis was given to student participation, the tutor initiated discussion by
more self directed group, in which students took more responsibility for their own learning and decided to select their own topic to prepare for presentation and discussion. The topics have, in the main, had a strong scientific basis, in philosophic, historical or social and economic terms. In addition, senior members (usually the Heads) of other departments have given talks on the work of their own subjects, followed by discussion.

In 1972, in order to take advantage of the special contacts and relationships possible in these tutorials, both from staff and student points of view, this work has been continued by the Head of the Institute.

5.52 Self-teaching In 1971 (for 1 term) and 1972 (for 2 terms) a number of self-teaching situations have been presented on a circus basis during a time-tabled morning period. These were all programmed and self-sufficient. Apart from those discussed in 'EXPERIMENTAL LEARNING MATERIALS', these have been largely designed to give first-hand practical experience particularly in the first term when there was otherwise no laboratory course. Although mainly Physics, e.g. ray optics, mechanics, they now include some Chemistry, e.g. tape-slide presentations in atomic structure and the periodic table; some practical work being in preparation.

Some of these were designed in conjunction with a (second) schoolteacher fellow †, in electrostatics and current electricity, which could be carried out anywhere in the University.

5.53 Progress tests and examinations

In addition to the final examination (and in later years to the Programmed Courses' Chapter or Unit tests), each teacher

† C. Cottrell; who will report on this work to Faculty 4 of the University of Surrey, which funded the research project.
has given one or two evenly spaced tests in order to help
the students and receive feedback about student progress and
difficulties. Multiple choice questions have been used in
Mathematics, Chemistry, in research/progress tests in Physics
(by kind permission of the lecturer in place of his usual test),
and in the programmed course in Physics, which consisted of
the hardest of the end of chapter problems.

The final examinations have consisted of either short
answer types with no choice of question (Physics); more lengthy
composite questions with choice (Mathematics); multiple choice
in conjunction with a choice of short essay type questions
(Chemistry); problems based on the Units in conjunction with a
choice of more lengthy and difficult questions (Keller plan
calculus) and a composite of matching type, multiple choice -
similar to the chapter tests - and short answer types - related
to the end of chapter problems - (programmed Physics course).
In this last, students are told in advance the function of each
part of the examination with respect to the course objectives.

The results of these examinations (in 1971-72 together
with coursework) in conjunction with reports on students, are
sent to departments chosen by students in order of their preference
for the continuing course. Each student then continues his
studies in the department of his highest choice which considers
his first year performance adequate.
6.1 Introduction

6.1.1 Course appraisal

As there is some discussion of the meaning of evaluation as applied to educational courses, the evaluation component of this research needs to be defined (see Appendix 7). It is, hopefully, thought of as being a 'common sense' approach, in that an initial period of observation and discussion was adopted in order to begin to understand the points of view of the course teachers and the students and the full complexity of the real situation. From this work, the need for a close examination of some of the problems arising was seen, and some potential solutions explored. In addition, some criteria for evaluation were established.

Thus, in appraising this course, and in particular the first year, extensive observations of the course, in particular of what was happening in the classroom, what was intended to happen, both in the classroom and in subsequent years of the course and students' perception of what was happening, form important areas where information was gathered.

In this chapter, information is presented about the success of the courses in terms of student progress through them, and about teacher and student comment, particularly about the first year of the course. In 'EXPERIMENTAL LEARNING MATERIALS' information is presented about some attempts to solve particular learning problems, and in 'OTHER EXPERIMENTAL WORK' further information derived from test scores, a questionnaire and some survey information is presented.

6.12 Some criteria Criteria which have been used to evaluate the success of the course have been both positive and negative. Among the positive are: the performance of the students compared to more "regular" students in examinations, laboratories and tutorials; perception of their own difficulties relative
to those "regular" students; the classes of degree awarded; the acceptability of the students to teaching staff, particularly in the latter parts of their course, and the number of students who would not have been eligible for a non-science degree but who succeeded in Science. Among the negative are: the proportion of students who opt to follow courses not in the scheme, whether Science based or not, whether at Surrey University or not, and the length of time taken to establish which students will not be successful.

6.2 Evaluation against objectives

6.21 Two kinds of objectives

Ideally, one important component of evaluation of any course is that which is carried out against objectives, i.e. such statements of course goals as are demonstrably achievable. A course which is successful in achieving its objectives will produce students who have acquired the knowledge, understandings and skills and show the attitudes specified in those objectives. Since in practice, course goals are specified rather generally and non-specifically as aims, to be furthered, this normally means that teachers would disagree about the extent to which objectives have been achieved through making different interpretations of the meanings and measures of these goals. It follows that objectives should be specified in one of two forms in order to be useful in evaluation:

(i) they should be fully behavioural, containing both the important conditions and the standards of the performance,

or

(ii) they should be less specific about the behaviour to be learned by the student but contain examples of the kind of appropriate test and acceptable examples of successful performance of the test.

An objective of type (i) would be so exactly stated that the evaluation measures or items (which could be examination questions, practical tests, projects, open-ended experiments, or any other non-subjective test situation) would be obvious and incontrovertible. Such measures are called criterion
An objective of type (ii), containing a very general statement, or aim, has potentially a great variety of possible measures and hence a large number of more specific objectives associated with it, each of which will normally be controvertible as they are implicit rather than explicit.

That such general statements of intent are very useful indeed in helping develop a new curriculum is clear at least from the Nuffield projects and from the North West Regional Project, as well as, for example, the American science programmes. In these, the statement of aims was a large step for the teachers concerned, the aims they produced implying great changes in the curriculum of their pupils. In these cases, the books of tests, or other assignments, or the evaluation teams who took over these aims, clarified these statements by providing clear examples of how they might be tested and thus demonstrated as having been achieved.

6.22 Examples of objectives The following objective is an example showing the characteristics of both types of objective discussed:

Given EITHER the motion of an object, represented by one of:

(1) numerical data
or (2) graphical representation
or (3) functional representation

OR situations and all necessary apparatus from which the student can extract one pair of these data sets;

ALL students will be able to:

(a) calculate (to a required accuracy) without interpolation other quantities not given,
(b) represent the motion graphically and
(c) demonstrate their knowledge and comprehension of the concepts and principles involved by making statements about how the position, velocity and acceleration of the object are changing with time (using elementary expressions such as
An example of type (i) is: "given any quadratic equation, all students will be able to calculate both roots (real or complex) with or without a desk calculator, without the use of notes, all values to be accurate to 0.1%".

An example of type (ii) is: "Students will be able to show understanding of the principles of basic electricity. They will be able to answer questions like:

(a) "At what rate is energy produced in a resistor \( R = 10 \Omega \) carrying a current \( I = 2.5A \)?" etc.,

and

(b) "Write an essay on conduction in metals - bring in such concepts as voltage, resistance, atoms, crystal conduction bands, dissipated energy, and relate these in a complete and fundamental way" (plus model answer and marking scheme)."

Another example of the second type: "The student will demonstrate a favourable attitude towards the Chemistry course, by seeking out at least one book not on the recommended reading list and trying to get other students to read it."

6.23 Problems of objectives The principal arguments against making a complete specification of objectives for a course are:

(1) thousands would normally be needed,
(2) adequate understanding would ensue if only a fraction were achieved,
(3) they would have to be sampled in the test,
(4) (2) and (3) are carried out in the traditional examination, without the tedium of writing all the objectives.

Thus, most teachers would say they have an implicit knowledge of what they were trying to do and given the freedom would effectively specify their objectives by the examinations they set. However, in practice, a syllabus and an examination effectively define objectives for most students and teachers.
Objectives of the B Courses

In the first year of the B courses, teachers have something of this freedom, but are constrained by the needs of the next stage. Thus they have a goal to achieve, 'that after the first year students should not have any greater difficulty than students entering with science 'A' levels'. This goal can be interpreted in a number of different ways in developing it from an aim to an objective. One way would be to state, 'the performance of the B group of students in any subsequent examination should not show any significant difference from that of the corresponding A group using any appropriate statistical test'. This effectively defines the objective in terms of these examinations considered appropriate by the departments' lecturers. This, though not normally an acceptable objective, is a valid statement in this case in view of the original goal, which involves two groups of students. In addition, this type of evaluation is likely to be acceptable to interested departments, inside and outside Surrey, as in the last resort, most academics have faith in the meaningfulness of their own examinations (see Examination Success) as a component of student assessment.

However, it might be that to achieve this objective, the Arts group of students might have to work harder, under greater difficulties, or they might have similar difficulties of understanding and coursework but perform poorly in Science examinations for some intrinsic reason. The latter point was not investigated, but the former will be taken into account in this evaluation.

Equivalence to 'A' Level

Potential receiving departments, and other University departments, being used to the majority of their students having specific 'A' levels, ask "How does the Introductory Science Year compare with 'A' level?". Although this first year cannot be considered as a substitute for 'A' level, nor could the students be expected to sit 'A' levels, this is a fair question. It presupposes that, at least in the knowledge and skills selected by the tutors as being relevant to future success, that equality in performance at the beginning of the course means future equality in performance. Receiving
Apart from the observation of the actual progress of the students, supplementary information has been obtained on this question, and is presented in "OTHER EXPERIMENTAL WORK".

6.3 Examination Success

6.3.1 The examinations  In their second year, students took the PEMS examinations, shown in Table 8. The Table shows that eight courses and examinations were taken by students, irrespective of department. However, the Physics and Electrical Engineering students took all eleven courses in common, and students of the Chemical Physics department followed only one different course in the second term. Students of the Metallurgy department took three of their eleven courses quite separately from any of the other departments. This difference was removed for the 1970 and 1971 entries when the PEMS course contracted to 1 term; but this change and the increasing range of courses followed by the students (Table 9.) makes inter-year evaluation more complex and less definitive.
Table 8

PEMS Examinations

<table>
<thead>
<tr>
<th>TITLE OF EXAMINATION</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Up to 1971</strong></td>
<td></td>
</tr>
<tr>
<td>Structure of Atoms</td>
<td>SA</td>
</tr>
<tr>
<td>Mechanics of Particles</td>
<td>MP</td>
</tr>
<tr>
<td>January Examinations</td>
<td>W</td>
</tr>
<tr>
<td>Chemical Thermodynamics</td>
<td>CT</td>
</tr>
<tr>
<td>Mathematics 2</td>
<td>M2</td>
</tr>
<tr>
<td>Electricity 1 *</td>
<td>E1</td>
</tr>
<tr>
<td>Electricity 2 *</td>
<td>E2</td>
</tr>
<tr>
<td>Structure of Molecules</td>
<td>SM</td>
</tr>
<tr>
<td>Properties of Materials</td>
<td>PM</td>
</tr>
<tr>
<td>April Examinations</td>
<td>STPE</td>
</tr>
<tr>
<td>General Studies *</td>
<td>GS</td>
</tr>
<tr>
<td>Shaping and Joining of Metals</td>
<td>SJM</td>
</tr>
<tr>
<td>Thermodynamics &amp; Kinetics 2</td>
<td>TK2</td>
</tr>
<tr>
<td>Physical Chemistry</td>
<td>PC</td>
</tr>
<tr>
<td><strong>From 1972</strong></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>M</td>
</tr>
<tr>
<td>Electric Circuits</td>
<td>EC</td>
</tr>
<tr>
<td>Properties of Materials</td>
<td>PM</td>
</tr>
<tr>
<td>January Examinations</td>
<td>WQ</td>
</tr>
<tr>
<td>Atoms, Molecules &amp; Crystals</td>
<td>AMC</td>
</tr>
</tbody>
</table>

(* These courses ran for two terms).
### Table 9:

**Student options for the second year**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td>5</td>
<td>8*†</td>
<td>6</td>
<td>2*†</td>
<td>1</td>
</tr>
<tr>
<td>Electrical Eng.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>0</td>
<td>1</td>
<td>5†</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>0</td>
<td>2*†</td>
<td>1*†</td>
<td>4*†</td>
<td>1</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

| (Human & Physical Sciences) | 0 | 1 | 1† | 1 | 1 |
| (Human Sciences)             | 0 | 0 | 0 | 0 | 2 |

* One unsuccessfully in the second year

† One unsuccessfully in the third year

x One of these accepting a place in another University to read Physics with Electronics.
6.32 Examination performance

Some examination score distributions are shown in Table 10 for the combined group of students (1969 entry) compared with the combined group of 'science entry' students, and in one case for a single department. These indicate two examples where B students' performance is significantly* less than that of their colleagues, two where the performance is not significantly less, and one where it is greater but not significantly so. On the histograms are shown the mean scores of the two groups and a range corresponding to one standard deviation above and below the respective mean. (Since no meaning can be attached to the absolute value of any particular score in any of the examinations, no numerical values are shown for the scores. In addition, it is not realistic to compare the performances of students of the different departments involved since any co-operative venture such as two terms common to four departments involves a compromise, the different courses and their examinations have weights which vary from department to department. Raw scores are shown in the histograms as, though the examiners normalise each examination to 50%, they do so without normalising the standard deviation. All comparisons must be made internally, specifically to each examination in each separate year.).

Two statistics are displayed with each histogram, students t and Mann-Whitney z. The former is a parametric statistic, which assumes that the numerical value of a student's score has a certain significance; the version calculated for the purpose of this analysis assumes that the two groups of students being compared may have different variances in their scores11. The latter is a statistic which is non-parametric to the extent that the ranking of a student in a group is the basic measure of his performance12. (These statistics are discussed in Appendix 6).

6.33 Conclusions from the scores

The first and most important conclusion which may be drawn from a brief examination of the histograms is that broadly, the students scores are distributed in a manner similar to those of their colleagues, i.e. they are not consistently all at "the bottom of the class". A

* at 5% level
Some score distributions (PEMS 1969)

Structure of Molecules
(1 dept)
\[ t = +1.2 \quad z = +0.9 \]

Structure of Atoms (3 depts)
\[ t = -0.4 \quad z = -0.5 \]

Waves (2 depts)
\[ t = -0.4 \quad z = -1.5 \]

Electricity 1 (3 depts)
\[ t = -2.4 \quad z = -2.2 \]

Mathematics 2 (3 depts)
\[ t = -3.0 \quad z = -2.2 \]

* shaded areas denote B students
There appears to be a tendency for the group, or a significant proportion of the group to score lower than would be expected from a random sample of students drawn from the control group. This is shown by the significant differences in some specific examinations and the tendency of the group to score slightly lower in most examinations. Such differences must be interpreted with great care, however, particularly in view of the small number of students in any one group.

6.34 The 1967 Group
The first group of students took these examinations in 1969, and performed as well as their Physics A colleagues. In five cases they performed slightly less than average, in six, slightly better; in only one of these was the difference significant, in General Studies. It is significant that this performance has continued throughout their course until graduation, when, although there were no high honours awarded, their degree classes were not markedly different from their colleagues. It must be remarked here that evaluation based on examination marks of Part I is not possible in view of the complex structure of the examinations system in the Physics department. This involves course credits, an α/β course system examination and other marks.

The students graduated with one lower second and three third-class honours, and one pass degree, one of these being after a voluntary year away.

6.35 The 1968 Group
This group performed on the whole lower than the comparable Physics A group in nine of the eleven examinations. This in itself is a significant result (p < 0.05 - binomial). In three of the tests (Mechanics of Particles, Electricity I and Special Topics) the difference is significant (p < 0.05) in terms of student ranks. This evaluation is, however, against the null hypothesis. The objective, when translated into statistical terms should read "the students will perform at least as well as their 'science entry' colleagues". In this case, more of the results show significant differences (Waves, Electricity 2, depending on which statistic is used). In addition,
examinations is significantly lower (p < 0.05 1-tailed). Also, comparing the grades awarded in these examinations (based on normalised scores) the group as a whole collected nearly twice the number of Doubtful and Fail grades as the comparable Physics A group and half the number of outstanding grades ($\chi^2 = 19.1, p < 0.001$). Any other statistical test based on the marks awarded in these examinations (Median, $z = 2.59, p < 0.005$; Quartile, $\chi^2 = 14.8, p < 0.002$) yields a similar result.

It is notable that the majority of fail grades were obtained in three examinations and nearly half of the total in the two Electricity examinations.

Thus, this group cannot be said to have performed as well as the Physics A group, two of them subsequently failing to satisfy their examiners at the end of their second year.

The Part I examination results of the students who remained in the Physics department indicated that they performed marginally worse (including 1 failure) than their Science colleagues, but the difference was not great. The one student who transferred to the Metallurgy department was referred in one of his subjects and resat his examination successfully at the end of his industrial year. Another student, who transferred to the Physical Sciences course, withdrew voluntarily (though successful) for a year, returned in 1971 and stayed one term before finally leaving.

This group obtained one upper second-class honours, and three pass degrees (three of the students have returned after an industrial year). In addition, two students who transferred to courses in other Universities, received first-class honours (Geology) and lower second-class honours (Geology and Geography) respectively. One of the students is now pursuing research for a Ph.D., another lecturing in Geology at the University to which he transferred.

6.36 The 1969 Group This group divided at the beginning of the second year, half continuing in Physics, all but one of the rest in Metallurgy.
In all examinations taken by students of the three departments concerned (except General Studies) the students performed less well than the combined A groups. This was true of their average marks of all their respective examinations. This was significant in Mathematics 2, Electricity 1, Properties of Materials, in both scores and ranking (p < 0.02). However, in view of differences in performance between both the B groups and the different departments (science entry), the departmental groups should be treated separately.

The students who opted for Physics did not differ significantly from the Physics A students in performance in any examination. The students opting for Metallurgy scored and ranked on average equal (one case) or lower, in every single examination, than the Metallurgy science entry. The differences were significant in Mathematics 2, Electricity 1 (p < 0.05 for ranks) Properties of Materials (p < 0.005), Shaping and Joining of Metals, and in the average scores (p < 0.05 for ranks).

In the end-of-year examinations for those students who failed to satisfy their examiners in PEMS, which included three out of the five B students, each of the students was able to satisfy the department that he was capable of continuing the course. At the end of the third year, however, one of these students failed and another was referred in one subject.

The metallurgy group will be a most important group from the point of view of transfer from Arts to Sciences, as the department declares a strong interest in management, offers language and economics options, uses mathematics less extensively in its courses than in Physics (which also offers an economics option) and develops different practical skills. It may thus be that a student who might not have succeeded if Physics were the only option, would succeed in the different environment of the Metallurgy department. In this connection, it is noteworthy that of the six students so far accepted by the
6.37 The 1970 Group  Of the eight students who continued into the second year in subjects of the scheme (including Mathematics) one student failed, one withdrew for medical reasons and so far as is known intends to sit the end of year examinations, another withdrew after being directed (along with 50% of the class) into the pass degree 'stream' in Mathematics. The remainder performed near or above the average of the 'science entry'.

6.38 The 1971 Group  Of the eight students, one withdrew early in the second year, two have performed somewhat below average and two somewhat above. The two students who continued in Biochemistry have not yet taken examinations but have reported severe difficulties with much of the Chemistry component of the CABBS course, taken in conjunction with the honours Chemistry students; one of these has transferred to Human Sciences. These difficulties have led to a revision of the course for future Biochemistry B students.

6.4 Student comment on the first year

6.41 Student interviews

From the beginning of the project, when the 1967 and 1968 entry were nearing the end of an academic year, it was considered most important to keep in close touch with the students to determine their problems and successes, their attitudes to the course, the University and the other students, at all stages of their course. Particular emphasis was placed on how the first year equipped them to join with students with regular science qualifications and how their perception of the first year changed with time.

Accordingly, it was decided to seek out the individual students of the first two groups to discuss with them their reactions to the courses they had taken, the outstanding problems which remained for them, how well they thought they were adapting, their personal histories and reasons for changing to science, their perception of the methods used in their first year and suggestions for improvements and their
These interviews, both formal and informal, were carried out from time to time, as the occasion arose at various places in the University campus conducive to informal discussion, in coffee bars, bars, student rooms, in the open air or occasionally in a tutorial room. A personal relationship was established with the majority of students, all being apparently willing to talk about their experiences at length.

All discussions were confidential to the extent that difficulties were allowed to be communicated to lecturers anonymously. Reciprocally, it was considered most important that no criticisms of University teachers should be condoned to the extent that these were agreed or discussed in view of the privileged nature of the project.

In fact, however, whilst offering criticism of the course and aspects of the teaching, the students have often been as critical of themselves, some being prepared to admit at the end of their first year or later that they were "fundamentally lazy". This self-criticism makes their observations of the course all the more meaningful.

6.42 Mathematics Mathematics is seen by virtually all students as the most important part of the course and they did not perceive any better way of conducting the course. The personal relationship developed in tutorials, the lecturer's concern for their growth in understanding and skills in Mathematics, the feeling of security given to the students by the integrated lecture-tutorial approach and the importance of Mathematics leads to a high degree of motivation towards following the Mathematics course. Lectures were seen as indispensable in spite of the generally agreed high quality of a particular programmed text which had been used by several students as an adjunct to their course. They considered their notes good, valuable even for second year examinations.
Students generally reported that they responded to the speed of this course, worked hard and attended well. Many students, however, reported difficulty in remembering Mathematics done, in many cases, several years previously. Other students reported a general weakness initially which led to difficulties in the earlier parts of the course. (This led to the Mathematics preknowledge survey and associated remedial work reported in "OTHER EXPERIMENTAL WORK"). Others reported growing difficulties which seemed to be cumulative, some parts of the course not being understood in any way at all. For some students these difficulties continued for another year or more, e.g. in logarithms and exponentials. Such students clearly need a more individualised method of instruction as well as practice in the basic skill of using logarithm tables. When possible changes in the course are discussed, many students suggest that the syllabus should be extended and that more time should be spent on the course, others suggest more time only. Very few criticisms of this course arise: the value of studies of conics was questioned, the need to appreciate more fully what a differential equation is and the need to relate the Mathematics to Science, showing for example that the introduction of Mathematical methods into Physics produced simplification rather than complication as stated. All these are retrospective, made at the end of the second year and later.

The introduction of the Keller plan for the Calculus part of the course, particularly with its initial revision of necessary 'O' level Mathematics, has generally been welcomed. On the positive side, students have reported a desire for a more widespread adoption of this approach to the courses of subsequent years, appreciating the self-paced nature of the work, and the thoroughness of the learning. On the negative side, students have reported difficulties with many parts of the course (which, though a tutor is present

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† here the Nuffield 'A' level Physics has a potentially powerful method
In addition, they have reported difficulties with parallel parts of the course which require certain principles and techniques of calculus covered in time in previous years, but not yet met by students working slowly through the plan. Some students have expressed preference for the lecture-tutorial method.

6.43 Chemistry This course is seen as a demanding one by the majority, stimulating many to read and work hard. Many students, however, have difficulty in perceiving how to order the large amount of information presented rapidly. They consider the lecturer's way of looking ahead and building up his approach towards a definite goal good (advance organiser) though it is true that many students can only piece together much of the course towards the end of the year and even into the second year. At this stage, the majority of students look back on a good, very helpful and very interesting course, though it is only then that some perceive the utility of the course as part of a Physics degree. Then, they even find they can teach students with Chemistry 'A' level the modern approach to such things as the benzene ring.

A problem for the Chemistry course has been highlighted by severe difficulties in Organic Chemistry and lesser difficulties in Physical Chemistry, experienced by two students in the second year of their Biochemistry B course. Earlier difficulties reported by Metallurgy students in the Physical Chemistry of their second year appeared to be related to the first year course in that they then experienced difficulties with its Mathematical content and attached less importance to the course than they should, because of the relatively small weighting given to Chemistry in the course as a whole.

The Biochemistry course differed from this in a number of very important respects, particularly in that the students followed the honours Chemistry course as well as Biological subjects, and that the importance of Mathematics and particularly Physics was somewhat less.
together with any transferring to this subject, have been required to complete their first year course with at least six weeks vacation study in Chemistry. In addition, a decision was made that no students would be accepted in 1973 for this course, until the results of the 'correction' are known, unless they already have substantial experience in Chemistry (or Biology for the related Biological Sciences).

6.44 Physics Since the course started off as Physics B, Physics has from the beginning occupied the greater part of it. Students have always been conscious from the time-table weighting alone, that Physics was very important. The approach to the teaching reflects this in that, as a core course rather than a service course, there are a large number of concepts and principles to be mastered as a firm foundation for later years. This often means that subjects have to be learned for their own sake, which many students find difficult to accept, reporting the need to see direct relevance in each piece of work and the large interconnecting ideas of physics. The students generally felt that the course progressed slowly and many could not distinguish the concepts and principles being taught while exceptions to these are presented at the same time. At the same time, the students comment most favourably on the presented notes, as they are full and complete, even though in parts of the course they are not understood. Some of the students did like the complete picture which was given and saw the relevance of the details given, perceiving how the large ideas of physics permeated the work; to this extent it is not certain how ability, method and selection interact in promoting success.

In a similar way, the tactile tutorials, helpful to many, confusing to some, indicated again the limitations of a single method of presentation where there is little time for students to become "acclimatised" to new ways of thinking and approaching their subject. About half the students attended, reporting that they derived benefit from the attempt to provide the physical picture as a complementary view of the subject. A few students
asked to be excused from these tutorials because they were confused by the presentation of material in alternative forms. In practical classes, a tutor has commented on the speed with which students grasp the essential ideas: in contrast, another tutor has expressed difficulty in getting the group actively responding in tutorials though this varies from year to year.

In other parts of the first year course, students who have given ten minute talks in seminars reported that they derive great benefit from the preparation for these and the programme used as a basis for the Electricity course after initial doubts proved quite popular, students working through every section of this substantial work.

In this connection, it is apparent that the students find Electricity the most difficult topic in the first two years of their course. This may well be due to the rather more abstract nature of the topic. After the results of the 1968 entry were known, the course was revised to become more extensive. Although it is difficult to perceive the effects of this in PEMS in view of the splitting up of the students who were a different group in any case, tentatively, it would appear that an improvement was shown. The evaluation position is rather more difficult for the 1970 entry as the PEMS course itself is changing. Another complication is that for reasons quite unconnected with the above problems, the lecturer in the Electricity course was changed in 1970.

6.45 Other observations The PEMS stage itself is one which is found to be particularly demanding, generally much more so than the Introductory year. At this stage, many, even the most successful students, have expressed inability to further their stated interest in new subjects by wide reading in spite of the overlap between this stage and the previous one and the revision which is conducted, due to the high work load. At this stage, too, many students, irrespective of
rather than those which they do not, responding slightly unfavourably also, like many of their Science colleagues, to the "conveyor belt" or "battery hen" atmosphere engendered by the combined lectures to 150 or more students.

The attendance of students in different parts of the course (particularly in the first year) reflects this to a certain extent. A substantial minority have disliked certain approaches, whether on grounds of rapidity or slowness of syllabus coverage, or confusion, or declining interest stemming from the need to adapt to a more restrictive approach to study, or lack of perceived relevance in a particular activity. Other individuals have elected to follow parts of the course on their own, by their own methods, often in consultation with a tutor.

6.46 General difficulties Some students have problems related to the need to change their way of thinking and organising their work and have commented in the First year on the problem of adjusting to the need to work at higher levels than they were previously used. They find that they are put into situations which demand application of recently presented knowledge as in solving course examples and problems. Not being used to this, some individuals have neither the confidence nor the problem solving experience to carry out these activities efficiently. They recognize that in the Sciences and Mathematics, the demand for this application and analysis of new situations leaves them unable to settle for a demonstration of knowledge and comprehension by writing about the subject in a way which shows wide reading. In this they have no doubt been used to reading widely and absorbing differing view points and expressing their understanding whilst keeping their individuality. Applying knowledge, at least in the way they are required, leaves them on their own, with only one definite solution to find. This is difficult for some to adjust to. Indeed one student, when confronted with unsolved course examples, often found poetry writing more attractive and produced a bookful of publishable poems! However, the fact that this kind of comment has been expressed
Arts subjects, does not necessarily support the view that the Sciences are more demanding in the way they are taught. Rather, it suggests that those who got by at knowledge and comprehension levels alone may well find difficulty when made to work at higher levels.

6.5 Extra curricular activities

The students seem as a whole to be particularly active in the University, including amongst their members for example a Union Vice-President, a Chairman of Entertainments Committee, several Society and Club founder members, e.g. Captain of Boat Club, Departmental Staff-Student Committee representatives and members of the Editorial Board of a University magazine. However, it must be said that the diverse activities of these students, including also drama, film, sport, music and, in particular, their response in the first year to the wealth of activities available at a University may play a part in distracting the students from their studies. Thus, one student, after repeating the first year, has successfully continued, performing above average so far in the second year of the course. Several others have reduced the level and diversity of these activities in response to the increasing demand of their courses. At the other extreme, high extra curricular activity may well have been a rationalisation of a reluctance to cope with the course for one student.

Their views on the merit of attaining an honours degree are wide ranging: at one extreme, one able student sees little intrinsic merit in any specific class of degree particularly as it has little bearing on the chosen career for which the subject has relevance; at the other extreme, one student reacted very strongly when it was suggested to him that a third-class honours degree might be a good achievement from an Arts background. Others have recognised very clearly the opportunity which the courses offer them, being willing to proselytise for the course.

The question of whether or not there are some students
who just will not succeed in Science, particularly in the 'hard' Science of Physics, has been raised. Many even of the successful students are very conscious of their own difficulties in mastering the mathematics of the course, particularly with reference to mathematical models, and the language of Physics. In many instances, they suggest that many of the Science entry students have had precisely the same difficulties but have been less willing to make these overt in tutorials. Indeed, one student, discussing difficulties with one very new and demanding part of the third year course, suggested that Science entry students found it more difficult as they were less used to learning completely new ideas, taking for granted that courses merely extended existing knowledge and viewpoints. Thus radically new approaches were unexpected and found difficult to cope with, in contrast to the experience of B students. This has been confirmed by several other B students who reported to other members of staff that they had greater difficulty than 'regular' students in many of their subjects, but that the position was completely reversed for other topics. Other students have reported observing no difference at all in relative difficulty, B students' less extensive background being compensated by a more questioning approach and the examination-oriented approach of their Science peers. Indeed, many tutors have reported, particularly in the first year, receiving extremely searching questions, of a kind not experienced by them before. However, in the author's opinion, these very same questions are asked in sixth forms by able students and others who are encouraged to question by their teachers. However, the deficiencies in mathematics and language have been recognised by staff and although they are conscious of being perhaps more aware of the B group, they are confident that there are underlying gaps and deficiencies in spite of the hard work put in by the successful students.

That many of these students do not intend to become Physicists is not in fact of great concern to members of the Physics department, particularly in the context of the growth of mixed courses (Physics with Economics etc.). Against this, however, is concern that in the few years since attention
other courses, graduates are finding increased competition for jobs, which may adversely affect these particular students if they opt for Physics in too large numbers.

6.6 Feedback

At an early stage in this project, it was concluded that the course organisers should decide to what extent they should help those students who are not adequately motivated at the beginning to succeed, or whose motivation and interest falls, to develop an appropriate motivation; that they should examine the extent to which some of the students who find their way to this course might succeed if given different approaches and a more varied and individualised learning environment. In this, professorial seminars in different subjects, close personal supervision, more regular and demanding work in all subjects particularly in the first term, visits to see research work, projects and other involvement with potential receiving departments, use of calculating machines, even short computer courses, integrated programmed learning of a varied kind and regular progress tests and experiments and other methods taken from parallel curriculum development programmes in Science and Mathematics, might all play a part in improving student performance.

In subsequent years, there has been response (reported in this chapter) to many of these points although a model for the curriculum, presented in the next chapter, was not accepted on economic grounds, and a simpler approach, viz, Keller plan, adopted instead.

In this response there was an attempt to produce a course design which, whilst being sensitive to the delicate problem of change in an uncertain direction, would be suitable for adults and would not shelter the students too much so that they would fail to cope with the more demanding situations in later years of the courses.
6.7 Overall success

The overall success of the course can be judged from Table 3. The overall pass rates for each year, defined as the proportion who continue into the next year (whether immediately, or after a temporary absence or a retaken examination) in courses of the scheme are 72%, 83%, 88%, with all final year students being successful to date. The projected overall success rate, defined in the same way, is 53%. The overall examination failure rates, (including those who transferred to other Science courses after examination failure and failures who successfully resit) are: 11%, 11%, 4% respectively.

Two significant groups remain, those who transfer to a science based degree course outside the B course scheme, whether at Surrey or another University (15% of the first year group) and those who for one reason or another withdraw from the courses, either temporarily or permanently, during one or other year of the course (so far 13%).

The overall success rates, defined as the proportion who continue in a Science based degree from each of the years of the courses, are 88%, 86%, 88%, respectively without regard to the success of transferring students. The overall success rate of students, defined in the same way, is 67%.

Thus, the success rate is below both the national average for Science courses and that for Surrey University, which is not different in this respect, although, in the years immediately preceding and following the beginning of this course, the success rates in some of the departments of the scheme were not very different from these, in some cases smaller, in some, larger. In addition, those with the lowest grades of 'A' levels have the highest success rates (though no student with the equivalent of 2 D's has performed better than average to date) and those with moderate grades, i.e. just below the minimum which might be acceptable for non-science courses, have the lowest success rates (40% who will fail).
point of view of continuation in the scheme, is not surprising. That many of those who do not continue, transfer to other full Science, or Science based courses, must be counted as a success, both for the students and the course. That success rates for the second and subsequent years are not higher, does, however, present some cause for concern, particularly in view of the support given to students in some of the departments in the scheme. However, if allowance is made for students who leave the course whilst still successful (including one who was not prepared to settle for a Pass degree) and genuine errors of admission into the second year, the rates increase to 91% and 92% for the second and third year of the courses which are very close to the national figures for normal three year courses.

Thus, this course presents a not unexpected high failure risk first year, a high withdrawal rate whether temporarily or permanently, and a high rate of transfer to other courses, mainly with strong scientific content. This suggests that courses of this kind are best administered in such a way as to provide options for students to transfer to other courses at a sufficiently early stage to avoid the wastage which would otherwise ensue.
7.1 Introduction

As one of the aims of the project (p.2) was a study of methods and as at the beginning of the project methods used in the course were conventional, a number of experiments in methods of teaching & learning were designed and tried out by the author to meet this aim more fully. They were based on extensive discussion with students and a feedback from examinations and were designed to match the course closely and act as learning materials, i.e. to help the students learn the concepts and principles of the course, to explore ways of promoting learning amongst students with an arts background and to exploit their qualities and interests. In most cases, the experiments were implemented with the close co-operation and support of the course teachers without whose help they could not have been carried out.

The Vibrations & Waves Laboratory took place on four consecutive practical afternoons in 1970. This experiment was not repeated, though most of the laboratory experiments designed for it (together with their work-sheets) were adopted in subsequent practical courses. The self-teaching situations were tried on an ad hoc basis mainly by volunteers, refined and made available for the time-tabled self-teaching morning.

The Programmed Introduction to Electricity was piloted in 1970 and subsequently developed and used by all the students of the 1971 and subsequent intakes.

7.2 Vibrations and waves laboratory †

7.21 The Problem Although the performance of the first group of B students in the PEMS waves examination was above average,

† Special thanks must go to Dr. P. Doidge, physics laboratory tutor at the time, for his permission, patience and help in conducting this experiment; to other members of the Physics and Electrical Engineering Departments for their helpful advice; to members of these departments, the A.V.A. Unit and Mr. R. Crogan of the Royal Grammar School, Guildford, for the loan of equipment.
difficulties reported by students in their first and second year courses, coupled with the below average performance of the second group suggested that the concepts and principles might be reinforced by a more concrete experience in this subject during the first year. In addition, many of the students had expressed the need for a more structured approach to their laboratory, in contrast to the more open approach they were experiencing, which, though satisfying others might have achieved more if these students had progressed to them at a later stage in their course. They also expressed the need for help to develop and maintain their interest in the course, and as many observers had reported a well developed group sense amongst the students, the solution attempted took advantage of this.

7.22 **Experimental design** Each student was required to select and carry out (with another) one of a set of lab. experiments and at the end of the afternoon contribute to a seminar on the theme of the set.

The themes were chosen to relate as closely as possible to the conceptual development in the parallel lecture course and were:

1. Vibrations and oscillations
2. Transmission of waves
3. Interference and diffraction of waves
4. Experiments with light.

The alternative experiments were chosen to give some variety, whilst concentrating on the basic theme, thus for example, theme 1 had the experiments:

(a) simple pendulum
(b) spring oscillations
(c) torsional oscillations
(d) loudspeaker vibrations
(e) V.L.F. alternating current.
The basic theme was the concept of an oscillation, the factors affecting (or not affecting) the characteristics of an oscillation, the mathematical representation of this and the similarity of different oscillations.

Each script was developed informally and briefly, retaining as much of the open-ended character of the normal laboratory as possible, that is, by ensuring active response to the script in which regular questions were asked, which would not simply tell the student precisely what to do\textsuperscript{15}. In this way, the succession of activities would form a natural sequence, for formation of the complex of concepts involved in the experimental science which included isolation of variables, accuracy of measurement, links with theoretical descriptions, the phenomena under study and with other phenomena.

An example of this approach follows, taken from the second experiment of the first theme:

2.3 "Suspend at rest one of the objects given. Gently pull it down. As it gets further from its position of equilibrium what do you notice about the force you are exerting? Release it and allow it to oscillate. (During this part of the experiment predict the effect of changing the mass - write your prediction down.)

Does it come momentarily to rest at any time during the motion? Where?

Where does it appear to be moving fastest?

Is the oscillation dying down?

Define for yourself the basic cycle of the oscillation - i.e. that amount of the motion which repeats itself.
In timing one cycle you must decide whether you start and stop your clock when the object is at an extreme point of the motion or passing the point where it hangs without oscillating.

2.4 Attempt to time one cycle. How accurately can you do this assuming you can time to 0.2 sec. using a stop watch or 0.4 sec. using a stop clock? Consider how you would improve on this accuracy.

2.5 Determine the time for one cycle \( T_1 \) measuring the amplitude of the motion, the unstretched length of the spring, and the mass of the bob. If the amplitude varies appreciably, estimate its average value.

2.6 Repeat for a different value of amplitude (say twice as great). Is the time \( T_1 \) measurably different? (You will have to estimate the reliability of \( T_1 \) and \( T_2 \) to answer this.)

2.7 Change the bob without changing the length of the spring. (Why?) Measure the time \( T_3 \). Is this different to \( T_1 \)?

2.8 Change the length of the spring by clamping it halfway down and measure the time \( T_4 \). Is \( T_4 \) the same as \( T_1 \)?

A fuller example is shown in Appendix 8.

The seminar itself was intended to contribute to learning through verbalisation of the experiences and concepts.
7.23 The experiment in action  In practice, student attendance was always high, their interest and application great. They welcomed the close link with the theoretical course and the clarification of many concepts which were made more real and relevant. For example, two expressed great delight when exploring the interference pattern from two loudspeakers to find that the two signals were out of phase at a position of minimum intensity, and said that here for the first time it became a real phenomenon. They found the structured worksheets positively helpful, although finding the questions a little contrived on occasions.

The seminar was less successful than expected as the students were generally not eager to talk, preferring to get away at the end of a hard working afternoon. Nevertheless they showed insight into their own experiments and interest in the others. Some expressed the feeling that there was little to discuss, as everything seemed so obvious, suggesting that the experiments were too successful in linking the ideas together. However, another important factor was the short time between completion of the practical work and the start of the seminar, insufficient for adequate consolidation and formulation of ideas for the seminar.

7.24 Student observations  Two contrasting student comments were particularly illuminating:

Laboratory Report

Lab sessions are always helpful, and programmed experiments are extremely so. Perhaps the printed guides should be given to the students one or two days prior to the session, so that queries could be cleared up and the whole experiment's worth be understood beforehand, thus saving time and frustration?
The seminar during the final period is very good in essence. It helps to explain one's experiment to the others verbally, and also to learn about the other experiments. The seminar does, however, cut the session rather short, leaving rarely enough time to complete experiments.

I think one should know more about the various experiments there are to choose from, together with their degree of complexity. This is mainly because some experiments may be more suited to a certain level of ability (academic) than others. And this way the students would not be making a more or less 'blind' choice.

I found myself more often than not failing to write any kind of report on the experiment. I think there should be pressed for, and marked.

The coffee break should be better defined, since some people (myself esp.) tended to take rather longer than necessary.

The instruction sheets were very useful. Their main advantage over being told what to do was that they could be referred to during the experiment to check apparatus was correctly set-up, and they also saved time.
The layout of the instruction sheet was clear but an introductory paragraph outlining the theory as applied to that particular experiment would have made them more interesting. For example, experiment 15 starts with a summary of last week's practical and then gives instructions for the experiment. A word on the aim of the experiment being to study waves by interference rather than using an oscilloscope would have been useful here.

The printed table for results was good.

The subject which the experiments illustrated did make the lectures more clear. One aspect of waves, the magnetic field at right angles to the electric field, could usefully be illustrated by an experiment if possible.

The experiments were too long. At the end of the afternoon it did not seem that many people would wanted to spend an hour discussing them. Also having to talk about an experiment if you were not quite sure what your results should or did show was awkward sometimes.
7.25 Conclusions To summarise the principles behind the design of this experiment and the implications for curriculum development, this field, like most in physics, is so rich in potential suitable experiences that individual students would normally follow a practical course consisting of a selection of a few important experiments from a large total. The students' experience would normally be enriched by demonstrations taken largely from the remainder. Thus, typically, teachers would put their students through the same limited practical course, not using these experiences to the full. The method outlined above, whilst in a sense giving the demonstrations to less skilled teachers, brings these 'secondhand' experiences nearer to 'firsthand' and greatly enlarges student experience. This is particularly important for students requiring an accelerated experience. In addition, whilst the range in level of the laboratory experiments in each set above is not great, this possibility exists so that individuals can select or be directed to experiments matching closely the current state of their knowledge and skills. The element of student choice, whilst not being exploited in this experiment adequately, has been found to increase student motivation through tapping their interests, even if this involved work not directly related to the set syllabus. As verbalisation is important in concept formation, the demonstration seminar has a dual function and should be utilised at school level. The role of the teacher would be to assist in the presentation of each experiment and in the synthesis of the concepts in the set and in the course.

† Earlier work by the author and colleagues, 1963-69, not published, involved a multiple choice laboratory of several hundreds of experiments of differing scope and complexity to cater for a wide variation of student interests and abilities.

†† The distinction between syllabus and curriculum is very important here.
7.3 Self-teaching situations in dynamics based on film-loops and photographs

7.31 Simulated experiments Harvard Project Physics film-loops and Nuffield/PSSC stroboscopic experiments form an excellent basis for the design of self-teaching simulated lab. experiments. Such simulations can short-circuit the essentially lengthy process of setting up and manipulating apparatus to produce data (in this case photographs) for analysis. This approach will always be valid where the development of the skills involved in the actual experimental work is secondary in importance to the development of the associated concepts (here; acceleration, momentum, energy, etc.).

7.32 Film-loops and their projection The film-loops (used in this experiment) were designed for Project Physics, to provide experiences for students which would normally be difficult and costly to provide in real life. They were as far as possible based on situations familiar to students and in which they were expected to find an interest. Where measurements were expected to be taken from the film, such as the displacement of some moving object, and elapsed time, the loops were to be projected onto a wall or other screen. As this method raises difficulties for the students, a projector table with a tracing paper screen was designed so that students could perform the simulated experiments seated in a comfortable position. In this way, the student would produce a record of the movements of the film (stopping the film at an appropriate time if that is required to make a tracing, together with measurements of time, using a stopwatch.

The loops have also been used in tutorials for whole-class measurement activities or for discussion.

† Special thanks must be given to Mr. R.F. Eatwell and the staff of the Library, to Mr. C. Aggett of the A.V.A. Unit and to Mr. D. Boud and Mr. S. O'Connell of the I.E.T. for their help and support in conducting this experiment.
7.33 Stroboscopic photographs These were photographs of simple experiments involving for the most part dry-ice pucks colliding or otherwise moving on a horizontal or sloping glass surface. They were taken in a professional studio and both slides and enlargements were made. The enlargements were produced so that the image of a 200 mm scale in the field of the experiment became 80 mm. Projection on the screen of the projector table was also arranged so that the demagnification was a simple ratio, in order to avoid calculation difficulties interfering with the learning of the physical concepts.

Life size projections have also been produced on white paper on a wall by a suitable arrangement of the projector in relation to the wall.

These exercises have been accompanied by a short demonstration and discussion in order to establish the concept of stroboscopy and its consequences for photography as well as to give an overview of the exercise.

Those students who attempted these units of work reported them to be beneficial, and produced at times impressive work.

7.34 Design difficulties There are intrinsic difficulties in using film-loops in self teaching situations. Instructions for stopping the loop at the appropriate time can be lengthy, as students have to see the loop through at least once, have a very clear idea of the aims of the work, and have grasped the procedures expected. As the scripts were written, rather than taped (in view of the problems of synchronisation at the time of the experiment) students have to alternate their attention between the two visual records viz; the screen and the script. This can lengthen the time required to complete the exercise to a point where it can become slightly boring.
Thus it is important that students should have easier experiences to begin with in order to grasp the nature of the work, before they attempt more complex exercises, which must be written exceptionally clearly and precisely. The use of currently available synchronous tape-film projectors (e.g. Phillips PIP) would not provide an adequate screen size to fulfil the requirements of this work. Alternatively, using a purpose-built unit developed around currently available cassette film projectors and tape players † would require more effort on the part of the student to manage the system, in which case, separate use of film and tape would be the best solution, as long as imperfect synchronisation can be tolerated.

† One such has been developed by Dr. R. Schulz of the Chemistry Department, University of Surrey, in conjunction with C. Aggett of the A.V.A. Unit.
7.35 **Summary** The use of single concept film or still photographs, accompanied by written scripts, requiring active involvement of students in conducting simulated experiments has been found a useful design for self-teaching situations in Physics. Substitution of a tape for the script would solve some of the problems of using film in this way, but would greatly increase the expense and time required for development, if perfect synchronisation were required. The simulation experiment provides a way of compressing the laboratory experience so as to maximise the benefit to students whose time is at a premium by cutting out unnecessary and relatively unproductive routine work and concentrating on the concept formation, where this is the principal aim of the selected practical work.

7.4 **Programmed Introduction to Electricity†**

7.41 **The Problem** When the performance of the students in PEMS examinations is compared to that of the regular science entry, it is clear that the largest deficiencies occur in the Electricity subjects. This fact, difficulties reported by students during their first and later years, and the results of the pre-knowledge survey in Physics, suggests that their first year experience in this subject required to be extended in time and strengthened.

7.42 **Rationale of the proposed solution** For reasons given below, it was decided to design a programmed text, based on a sequence of practical work, designed to develop the key concepts at a basic and fundamental level, to be given during the students' first term.

† Special thanks must go to W. Corns of Huddersfield College of Education, without whose programmed learning course and advice this experiment would not have been possible; and to Mr. S. O'Connell for his patience and tolerance in its implementation.
The timing was chosen for four reasons:

1. observed difficulties of students in understanding concepts of atomic size in relation to atomic number in the chemistry course suggested the need for support from suitable demonstrations or experiments in electrostatics.

2. there was demand from students for a greater intensity of work in the first term.

3. there was no practical work in the first term and,

4. probably most importantly, it would extend the time during which students could be thinking about the concepts by up to 50%. This should compare with the 1½ years students spend in the sixth form, the extended time allowing much more accidental learning as well as greater (deliberate) synthesis of the complex ideas presented during the course - thus any lengthening should be beneficial.

The method was chosen for four reasons:

1. because for many of the students practical experience was minimal in this field,

2. because the course was theoretical, and unlike in mechanics where there is contact with the real macroscopic world, no suitable model exists for the students other than the real situation,

3. the programmed method is flexible in use and powerful in action, and

4. a circuit board existed which made it possible to set up experiments quickly (i.e. in seconds).
7.43 The programme, objectives and assumptions and design The programme was devised after a selection of appropriate subject matter including for example concepts of voltage and its reaction to energy transmission from cells to circuit elements, charge and current, good conductors and relatively bad conductors and going as far as the two Kirchoffs Laws.

The objectives were designed to include not only behavioural indications of concept and principle learning but also the ability to set up given circuits and take measurements, as well as the ability to design circuits to satisfy given criteria.

Example:  **Objective 7**

Given all the components of List 1 and all the symbols of List 2, and directives to design circuits of the following types (i.e. equivalent complexity):

(i) a circuit containing switches and lamps such that the lamps will light only when both switches are activated;

............... 

(iii) two lamps in series, two in parallel, two of these lamps to be brightly lit (and correctly so predicted);

............... 

the students will be able to design circuits which meet the functional criteria (representing them diagrammatically), assemble any one, and demonstrate that it does meet the criteria\(^2\). 

The programme assumed little, viz the reading ability of an arts sixthformer, tolerance of different ways of repeating
something, the ability to read and interpret simple line representations of components, the ability to record numbers and manipulate them using basic arithmetic operations, and to use these operations on algebraic quantities.

The ability to interpret circuit symbols was not assumed, and the idea that a symbol could be used to simplify the representation of a circuit component and hence speed up communication about a circuit, was developed at an early stage.

Frame 2

During the course of this programme you will be assembling circuits using components represented by symbols in a diagram.

These circuits will normally contain one or more batteries each consisting of one or more cells.

![Battery symbol](image)

This symbol represents a battery containing one cell and two terminals. It is simplified to:

```
-\[\text{+}\]
```

or most commonly:

```
-\
```

the terminals being understood.
(The significance of the sign will be explained later in the programme)

![Battery symbol](image)

This represents a battery having four cells and five terminals. It is simplified to:

```
-\[\text{+}\]
```

or most commonly to:

```
-\[\text{+}\]
```

(a) On your response sheet, draw the symbol for a battery containing six cells (*__________).

(b) Now examine the "broken-down" battery and compare it with the symbols used above.
The concepts and principles were established, as far as possible, inductively in the belief that this method would lead to more effective learning\textsuperscript{22}. In addition, since one of the objectives involved design, the challenge of designing and setting up circuits given only the results to be achieved was built in.

The need to "start at the beginning" was well demonstrated by the delight a few students had in setting up their first circuit, to light a bulb. For these students the realisation that someone understood their needs and was happy to provide simple experiences was a great help. Nevertheless, the programme treated these experiences at a sophisticated level, being expected to go quickly from the inference that energy is transmitted somehow from a battery to the circuit, through the realisation that some energy may be passing through substances which apparently did not allow it\textsuperscript{23}, through simple operations on a table of resistivities to predictions of the effect of a variable resistor in series/parallel with two lamps in parallel in the first section of the programme. The challenge of circuit design appeared early enough in the programme to satisfy the more experienced. This placement of suitably challenging work is an important problem in designing work for a student body with wide range of experience.

Before the second, theoretical section of the programme, the students received a demonstration of several important phenomena in electrostatics, designed to induce the elementary principles. The demonstration goes on to show phenomena of current electricity through which electricity can be measured; finally the link to electrostatics with evidence for the mobility of the negative charge. These demonstrations were designed also to help the development of atomic concepts in the Chemistry course.
discrimination between "conventional" current and negative charge current with simple quantitative work on current and charge movement.

The remainder of the programme leads to Kirchoff's Laws through measurement and prediction with simple reasoning about circuits containing lamps as energy meters.

**Results** Because the small numbers of students imposed a long development time on the programme and because it was never possible to give the programme during the first term, it has only been possible to carry out a limited summative evaluation with one group of students. Results of the post test indicate 62 - 85% achievement of the objectives sampled, and gains ranging from 44 - 63%, although these were highest for the lowest level objectives (98% & 96% respectively). In spite of this, it has shown clearly the need to match the course to the students, to provide interesting and motivating experiences, and to apply standard techniques of programmed learning e.g. concept analysis and proper sequencing of learning experiences.

The students always worked well, whether singly or in groups, enjoyed the work, were stimulated to work together and asked difficult questions of any tutor present. This last demonstrated the difficulty of writing flexible learning programmes to meet fully the variety of individual needs, without the presence of a tutor, even for an occasional consultation.

7.5 **Self-Teaching practical in Measurement**

The self-teaching introduction to measurement was again designed for the first term, in order to introduce simple techniques of measurement and the concepts of experimental error and interpolation.

† Special thanks must go to Mr. S. O'Connell for his constructive help and participation in the design of this experiment and his support in its implementation.
associated rules and precision instruments together with a film-loop on using the vernier. Like the electricity programme it attempted to start with students knowledge and develop this, through simple experiment and measurement, at an adult level to give the students experience of variation in measured values, plotting of histograms, calculation of best estimate, and an introduction to the concepts of random and systematic error and the implied precision of stated values.

During the course of the programme, the students were introduced to the discipline of tabulating results, being asked why they should do so. No attempt was made to suggest that measurements should take on certain predictable values, but rather each measurement was accepted as valid in its own right. Students were expected to answer questions like "how do you think you would choose the best estimate of the length of the board provided?" and be able to answer "the most frequently occurring value" or "the average"; whilst confirmation suggested that no one measurement can be preferred so some means of combining them all together would be most reasonable, etc.

In practice, the large (~0.5 mm) variation in measured values (compared with an expected variation of ~0.2 mm in 120 mm using plastic rulers) seemed to be sufficient to excite student interest in what could have been a trivial task - the majority being very surprised at its magnitude and producing all sorts of suggestions as to the cause of the variation.

As a package, this was stimulus-centred in the sense that response was expected directly on only a small fraction of the information which was presented, which seems to be a simple way of catering for wide variation in student ability and interest, allowing each student to learn as much more than the minimum (on which response was required) as the student felt appropriate at the time. Thus some students responded indirectly to most of the information presented through a
lengthening the time required for reading significantly, would still appear suitable for use in other courses or in 'remedial' situations where basic concepts and techniques need to be learned together.

7.6 Integration and management of a variety of experiences

Development of these ideas in the design of a course unit would present considerable management problems in the appropriate sequencing of basic reading coursework, cassette and other films, tapes and slides, programmed materials, experiments, project investigations, informal tutorials and lectures together with optional enrichment materials of a similar nature, particularly with a large class. Nevertheless, recent projects, e.g. Nuffield Secondary Science 'O' level and 'A' level; Harvard Project, have progressed considerably in this direction.

Figure 11 presents a model for the management of a course containing many presentation methods, as well as a core course and additional enrichment material 27. For this purpose, it is assumed that there are alternative ways available both in medium and treatment for a student to interact with the knowledge of the course unit and that, in consultation with a tutor, selects from these and similarly designed available enrichment materials. Whilst at least the basic learning materials would have been designed after appropriate conceptual analysis and the overall management might use network analysis techniques 57; management of the separate units should be ultimately left to the individual student who, subject to tutor consultation and observation should be largely free to select from suitable learning experiences for himself.

Although the multiple choice aspect of this model, (presented by the author in a seminar in February 1970) was rejected on grounds of cost and preparation effort in relation to the small numbers of students on the course, it is notable that the unit structure has been adopted in the approach to Calculus (Keller plan) and Electricity adopted in the Institute in its part in the subsequent teaching of the course.
FIG. 11: STUDENT PATHWAYS THROUGH LEARNING MATERIALS OF A UNIT

DIAGNOSTIC OR PREKNOWLEDGE TEST

BASIC "MAINSTREAM"

TEXTS
PROGRAMMED MATERIAL
EXPERIMENTS
PROJECTS
SEMINARS DISCUSSION ILLUSTRATED LECTURES
COURSE WORK
TAPES SLIDES FILM

TUTOR
CONSULTATION DISCUSSION ADVICE CONTROL

REMEDIALLY WORK

ENRICHMENT

TEXTS
PROGRAMMED MATERIAL
EXPERIMENTS PROJECTS
SEMINARS DISCUSSION ILLUSTRATED LECTURES
COURSE WORK
TAPES SLIDES FILM

POST - TEST

UNIT
8 OTHER EXPERIMENTAL WORK

8.1 Outline

Other experimental work included tests and a questionnaire; designed to elicit information about conceptual difficulties, about background and about study habits with particular reference to problems involved in changing from Arts to Science.

These tests were:

1. a Mathematics preknowledge survey designed to explore the Mathematical knowledge and skills the students entered with and to help them commence their course more profitably;

2. a preknowledge Physics test, designed to explore the knowledge and understanding of students as they entered the course;

3. a Chemistry test, designed for comparison purposes in an attempt to evaluate the Chemistry course;

4. two Physics tests, designed to explore the conceptual development of the students, particularly in comparison with students following 'A' level courses in Physics in school sixth forms;

5. the adult test of intelligence, AH528.

The tests in (1)(3)(4) above are presented in Appendix 3. The questionnaire (Appendix 4) was designed to elicit background information, and included elements from other work, as well as
This chapter presents an account of each of these, and a summary of conclusions based on an analysis of these, in combination with other numerical information.

8.2 Mathematics and the preknowledge survey

8.2.1 Early difficulties in mathematics Discussion with students of the 1967 and 1968 entries established clearly that they found difficulty at an early stage in their Mathematics course in using and applying some of the knowledge and skills they had learned in school in understanding the new concepts of the course and solving the coursework exercises. These difficulties resulted in the students often being delayed in understanding the material of the course whilst they revised the elementary knowledge assumed in the course. This revision was seen to be inefficient, and best done at the beginning of the course.

8.2.2 The survey and revision work There was thus a need to establish for each individual a programme of work designed to give revision and practice of these elementary knowledge and skills assumed in the course. The solution proposed was that a test be administered to diagnose areas where work was required and direction given as to the kind of work which would give suitable revision and practice. The test would be a 'preknowledge' test\textsuperscript{29}, sampling only those concepts and principles actually used in the course and not specifically taught in it, the theory being that mastery of these would lead to a greater likelihood of mastery of the concepts, principles and skills taught in the subsequent course, irrespective of total Mathematics experience and achievement. The tutor at the time accepted this suggestion and collected items from a student text 'Elementary Algebra' by B. Rich\textsuperscript{30}, in McGraw-Hill's Schaum series) covering signs, brackets, substitution, solution of simpler linear and simultaneous equations, indices, factorisation, etc., and
appropriate to each question. This was found to be a very valuable introduction to the course by the majority of the students who were identified as needing the "remedial" work, since it had been at least two years since the completion of their 'O' level courses.

Though the test was designed by the course lecturer and administered by him in the first teaching period and marked immediately, all the follow-up work (including the post-test) was conducted as part of the research of the project. The results of the parallel post-test were very encouraging in terms of the knowledge gains indicated, nevertheless, the pre-test predicted accurately all the students who were to find great difficulty with the Mathematics course, showing that "deficiencies" were more than those indicated by the specific questions failed.

This experiment was repeated in 1970, with two revisions, firstly, the test was revised slightly, to remove items which were answered correctly by nearly 100% of the students, and secondly, with reduced follow-up, viz; the students received the results of the test and the recommendations about revision, but were left to themselves as regards their decisions about revision. This approach was found to be less successful, as a smaller proportion of the students who were diagnosed as requiring remedial work in fact did the recommended work.

8.23 Integration into the course

In 1971, the pre-test remedial work and post-test were integrated into the course formally. This was done when Professor Elton took the Calculus part of the course and operated the so-called Keller plan, in which students proceed at their own rate (subject to targets being met), proceeding from one Unit of work to the next after successful completion of a Unit post-test. Thus the "remedial work" became the equivalent of a Unit 0.

* The author is indebted to Dr. R. S. Taylor for this work and his subsequent support.
The test itself was extended slightly in the field of logarithms, to match more closely the revised course and also the Unit 0 texts, which were chosen to be "Programmed Reviews of Mathematics" by Flexer and Flexer. This series is designed for students following introductory courses in the Physical Sciences who have covered the material of the texts before, but who need revision, i.e. it "enables the reader to regain quickly and easily the mathematical proficiency he may have lost since high school". The pre-knowledge test was administered during Induction Week.

As in previous years, students received references to parts of the text appropriate to each question, and were required only to study to pass items in the post-test which they failed in the pre-test.

As in previous years, all students who had been diagnosed as in need of revision agreed that the pre-test was useful in demonstrating this need, i.e. to cover matters they had forgotten or not fully understood, the most notable areas being indices and the new area (for the test) of logarithms.

8.24 Deficiencies in the test

Two areas were found not to have been treated adequately in this revision work, viz; trigonometry and logarithms. Diagnostic items for the former were incorporated in the 1972 test.*

These difficulties highlight an important problem in the design of such preknowledge surveys in that it will not be sufficient to analyse a course for concepts and principles assumed to be understood and 'skills' assumed to be held.

---

* by J. Nuttall, the Keller plan postgraduate tutor, to whom the author is indebted for information about difficulties incurred in the years 1971-72 and 1972-73, and who extended the preknowledge survey to include trigonometry.
The level of such understanding will have to be established from actual experience of the students in following the course. Solutions can be in the extension of the preknowledge survey, or a restructuring of the learning sequence in the course.

Thus, although all students had done some trigonometry before, in most cases the trigonometric functions they had met had been defined in terms of a right-angled triangle, whereas the course textbook defined the functions in terms of co-ordinates on the circumference of a circle. The initial difficulty weaker students had in accepting these new definitions and relating them to already familiar concepts, was not overcome by the fact that the text went on to consider the definitions in terms of a right-angled triangle.

Similarly, all students had encountered logarithms as a tool for calculations and had learnt rules which they were able to apply adequately, but with little understanding.

8.25 A specific difficulty analysed The concept of logarithm has greater generality in view of its use in the description of many scientific phenomena and technical processes. In the course textbook, the logarithm was introduced, in a revision section, by a definition expressed by the formula

\[ 10^{\log x} = x \]

followed by the statement: "that is, the logarithm of a number \( x \) is the power to which 10 must be raised to produce the number \( x \) itself. This definition only applies for \( x > 0 \)" , and two examples:

- \( 100 = 10^2 \text{ so } \log (100) = 2 \)
- \( .001 = 10^{-3} \text{ so } \log (.001) = -3 \)

Students who did not remember logarithms were brought to a halt by this frame.
1. a concept was supposed to be learned through a statement of principle involving the very concept (using Gagné's definitions).  

2. $x$ appears on both sides (interference).  

3. the definition uses implicitly and covertly the concept of an inverse function, the cause of the interference.  

4. the students were unwilling to accept a definition.  

5. they had an inadequate concept of "continuous" and otherwise non-integer powers (except possibly $10^{1/2}$).  

6. the concept, function of a function had not been met.  

7. the concept of a function was held at a low level.  

(See figure 12a for a diagrammatic representation of the developmental links between concepts implied in this presentation).

Thus an alternative means of presenting the principle is required, after the concept has been learned another way.

8.26 A restructured learning sequence A new sequence of learning experiences involving a graphical approach and suitable revision of associated concepts, was tried on the students who had the greatest difficulty with this frame, and was found to help remove the barriers to learning in the text. The new sequence was not dissimilar to that of Eraut, in FUNDAMENTALS OF INTERMEDIATE ALGEBRA; which became available after the sequence was produced.

The sequence reorganised the links between concepts and is as follows (see also figure 12b):
1. Plot $y = 10^x$ for $-1 \leq x \leq 2$

(a) for integral $x$
(b) for the non integral values
   $x = -0.5, 0.5, 1.5$

revising the meaning of $10^{rac{1}{2}}, 10^{rac{3}{2}}$ using square root tables

(c) for $x = -0.75, -0.25, ... 1.75$

2. Show that in principle, $10^x$ is a meaningful quantity, whatever the value of $x$, and can in principle be calculated:

   e.g. $10^{0.95} = 20 \sqrt[10]{10} = \left(20 \sqrt[10]{10}\right)^{19}$, though it would obviously be tedious to work out the 20th root of 10. That is, if we can calculate one value, e.g. $20 \sqrt[10]{10} = 10^{0.05}$ then we can work out

   $10^{0.1} = 10^{0.05} \times 10^{0.05}, 10^{0.15}, 10^{0.20}$ etc.

   Similarly, knowing $10^{0.01}$ or $10^{0.001}$ ....... This leads to the idea of a "continuous" monotonic function.

3. Draw a smooth curve through the points.

4. Since by interpolation, we can get $y = 10^x$, whatever $x$, we can now look at any $Y$ and get the appropriate $x$ by interpolation.

   Try $Y_1$, $Y_2$ then $Y_1 \times Y_2$, $Y_1 \div Y_2$ using the graph.

   It works to a precision corresponding to that of the interpolation.

   Thus, given $Y\left(=10^x\right)$ we can always find the $x$.

5. This is so useful, we give it a name, i.e. the logarithm of $Y$ and a symbol, $\log Y$. In shorthand, if $Y = 10^x$, $x = \log Y$.

   Try a few more examples, then introduce tables of logarithms
as presented in a revision programme.

*4 attitude: willingness to accept definitions

concept: definition

2 interference

10 \log x = x

3 concept: inverse function*

5 concept: powers of 10, real *

6 concept: function of a function *

concept: function

* concept or attitude not held by student.

(Figure 12b) as presented in the restructured sequence.

10^{\log_{10} Y} = Y  

\text{summary principle}

x = \log_{10} Y  

\text{new concept}

\text{concepts and attitudes}

The activities are arranged so that the activity dimension links all in the lowest box for revision, e.g., reinforcing not only the concepts "10^{n/m}" through the examples, but also the concept "function".
6. Obviously, the value of x corresponding to a given Y depends on whether or not 10 is used as the base

thus if \( Y = 10^x \); if \( Y = 100 \), \( x = 2 \)

\[ \text{if} \ Y = 100^x \; ; \text{if} \ Y = 100, \ x = 1 \]

So the base matters and must be specified. In shorthand, we write \( x = \log_{10} Y \) to tell us the base being used.

7. Finally, if \( Y = 10^x \); where \( x = \log_{10} Y \)

another way of summarising all this would be

\[ Y = 10^{(\log_{10} Y)} \]

A possible advance organiser, or motivational factor, could be (after the derivation of the usual rules for \( 10^n \times 10^m \)) the suggestion that if numbers could be converted to the form \( 10^x \) then multiplication (etc.) would be much easier [ Thus, if \( 10^1 = 10, \ 10^2 = 100 \) then \( 10^{(\text{something between 1 and 2})} = \text{something between 10 & 100} \)]

The need for a development for adequate formation of the concepts involved in this treatment and subsequent work, is reiterated by difficulties experienced by a small number of students of earlier years in the second and even third year of their courses. These difficulties have been found in, for example, the solution of equations such as

\[ A = Be^{-CD} \]

for \( C \) from given data, or the plotting of points on logarithmic graphs or generally dealing with negative logarithms.
surveys makes assumptions which may be crudely put, that all things being equal, students who have relevant preknowledge will succeed in learning concepts, whereas students without it will not. In practice, a student may achieve a high score with less experience and higher ability to learn in the subject, with long experience and lower ability or after good teaching. Low scores may be achieved with limited experience, poor teaching, low ability, or simply lack of real interest in earlier courses. Thus students directed to remedial work may not need this direction and achievement of adequate preknowledge whether after remedial work or not, will be no guarantee of success in the subsequent course. Nevertheless, the success of the approach indicates that in attempting to match a course as closely as possible to the needs and abilities of students, both at the beginning of the course and during it, teachers should:

1. design a preknowledge survey after a careful and thorough analysis of the knowledge and skills assumed in the course,

2. formally integrate the survey (with its associated remedial work and post-test) into the course, as this has proved most effective,

3. analyse the hidden assumptions in sequences of learning situations in which difficulties arise so that a redesigned sequence can be based firmly on familiar concepts and proceed in steps which students can accept.

8.28 Implications That the above approach will lead to more effective learning, raises two issues, firstly that it is genuinely possible, with the correct sequence of learning experiences to teach mathematics to a level which surprises the students, and secondly, that doing so will not help some students, whose subsequent curriculum after the first year would not necessarily be planned in the same way. This latter constraint is a familiar one in a time of rapid development in school curricula and raises fundamental issues.
experience so far suggests that the proportion of students who would benefit from such an approach is greater than the proportion of students who would simply have their failure postponed for a further year due to the temporary help given to them.

The former point, whilst derived from a study of students with a supposed predeliction to science and selected for adequate mathematical skill, does have implications for school curriculum development in mathematics. That is, that given the right course, learning in mathematics can continue well beyond the level at which many allow it to stop.

8.3 Physics and the Physics tests

8.31 Rationale These tests were designed in an attempt to monitor the conceptual development of the students in Physics, both longitudinally and comparatively (with students of the science sixth) as the students would have somewhat shorter time than 'normal' (1:4 is not untypical) to assimilate similar concepts and principles.

The tests were designed on the principle of Bloom's Taxonomy\(^3\)\(^5\), in order to explore the degree of complexity achieved by the students in thinking about the concepts and principles of Physics.

The first test, a survey administered at the beginning of the course, was equivalent to 'O' level in standard * . This indicated that the students had a level of understanding equivalent to 'O' level in Mechanics but somewhat less in Electricity.

8.32 Item Bank The tests administered during the course †, separately in Mechanics (with a little Optics) and Electricity

* used by kind permission of A. E. Ashworth \(^3\)\(^6\), who developed the test as part of a study for a M.Ed. thesis, Manchester University.

† thanks are due to the course lecturer, R. A. Scobie, for permission to use these tests in place of his usual terminal tests.
published and mainly unpublished validated tests used for examination purposes in several countries. This assembly was felt to be an adequate substitute for the development of a validated test made from items developed and validated for the purpose, in spite of the different conditions of the tests, short-circuiting the lengthy and (in this case) uneconomical use of time required to do this. In this way, by the parallel use of the tests in schools, they were self-validating, though a small number of items did not reach the standards applied to objective test items. These items were stored on 8" x 5" perforated cards, which were punched according to a decimal item number (which allowed for grouping of items and variation of items); item type (multiple-choice, multiple-completion, etc.); level of complexity (knowledge, etc.); kind of interpretation required (algebraic, numerical, verbal, diagrammatic) and subject matter (Physics, Chemistry, Mechanics, etc.). Level of complexity, where not otherwise estimated (for G.B.) was established in conjunction with one or more teachers. (It had been hoped to make this Bank available to local teachers to assist them with their own testing, especially in view of the increasing use of objective testing by examination board, but considerations of copyright and secrecy precluded this. Nevertheless, an attempt to develop a suitable Bank, for use particularly at 'O' level was made, but which did not develop beyond a preliminary examination of the problem and the analysis of some tests used

† Thanks are due to the Educational Testing Service, Princeton, New Jersey, for permission to use items on a research basis, and to a consortium of Examination Boards which devised several hundred items for an experiment designed to establish objective testing at 'A' level.

†† Thanks are due to Dr. M.F.C. Ladd, of the Chemical Physics Department, who allowed a computer program to be used in work with multiple choice tests; and to K. R. Knight of the Physics Department, who wrote a FORTRAN program for a more extensive item and test analysis.

* Thanks are due to J. Crosby of Huddersfield College of Education (Technical) for this idea.
by these local teachers at a number of meetings. The principal reason was the enormous amount of work required in the development of a useful Bank. It follows that support for teachers in a venture such as this would be of great importance).

8.3 Results The results of these tests indicated that the students reached a standard at the levels of knowledge, comprehension, application and analysis in the Mechanics test in just over one term which was:

(1) superior (significantly) to that of students in one local Grammar School First Year Sixth (School A);

(2) superior (not significantly) to that of students in another local Grammar School First Year Sixth (School B),

(though slightly inferior to the "double-Mathematics and Physics" group and significantly superior to the group taking Mathematics, Physics and Chemistry 'A' levels);

(3) equal to that of students in the Second Year sixth of School A;

(4) inferior (not significantly) to students of a distant Grammar School second Year sixth (School C) and

(5) inferior (significantly) to students of a distant Public School (School D) second Year sixth.

In contrast, the students reached a standard in the Electricity test, which was inferior (in two cases significantly) to that of students of the Science Sixth, the differences being greatest for the Second Year Sixths.
T-test on Differences in Performance between Students in Introductory Year and Science Sixth Form

<table>
<thead>
<tr>
<th>Year (6th Form)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics Test</td>
<td>+0.60</td>
<td>0.0</td>
<td>+1.25</td>
<td>-0.64</td>
</tr>
<tr>
<td>Electricity Test</td>
<td>-</td>
<td>-</td>
<td>-1.08</td>
<td>-2.82*</td>
</tr>
</tbody>
</table>

* Significant at 5% or lower level.

In conclusion, students are learning concepts in Mechanics at a faster rate than comparable students in Science Sixth, and have only slightly less knowledge and understanding than those in the second year sixth. In Electricity, however, this is not so, and near the end of their course, have not learned so much as science sixth formers near the end of their course. This result, in conjunction with the results of the Physics preknowledge survey, confirms the need for a close examination of the complexity of this subject, with particular regard to its remoteness from everyday experience, seen in the examination results of students in subsequent years.

8.4 Chemistry and the Chemistry Test

This was designed by the course tutor at the suggestion of the author, in an attempt to compare the conceptual development of the students by the end of their course, with that of sixth formers studying 'A' level Chemistry. Another
course was an adequate preparation for the honours Chemistry course at Surrey. It was validated by students in the first year of Metallurgy and Physical Sciences courses at Surrey University. In this, the B students scored on average slightly lower, and achieved on average the equivalent of a moderate grade at 'A' level. Nevertheless, in spite of the fact that the test was geared more to the Introductory Year Chemistry course than 'A' level, and that the course was never intended to be equivalent to 'A' level Chemistry, this was seen as a most satisfactory result for the course. Unfortunately, it was not possible to make an adequate comparison at the end of the first year, as was intended.

8.5 The Questionnaire

8.51 The design This questionnaire was designed firstly to obtain background information from the students, secondly to find out how they organised their work, and thirdly to find out how they perceived their achievement in different parts of the course.

The questionnaire was based on those used in the investigations of Hutchings, Peterson & Parlett, as well as on two used in the University of Surrey in 1967. It also included questions specifically (rather than generally) related to the B students and their course, in particular, a rating of comprehension of different parts of the course (results presented in Appendix 2).

8.52 General information Apart from material reported in 'THE STUDENTS' of those responding to the questionnaire, who tended to be the successful students, owing to the timing of the questionnaire (just before or just after first year examinations, the weekly amount of time spent

† Thanks are due to Dr. D.S. Allam for designing the test and his support; and to students and staff of the Metallurgy, Chemical Physics and Electrical Engineering Departments for their co-operation.
Approximate times spent by students on studying on their own

<table>
<thead>
<tr>
<th>Time</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>4</td>
</tr>
<tr>
<td>1-5 hours per week</td>
<td>8</td>
</tr>
<tr>
<td>6-10 &quot; &quot; &quot;</td>
<td>4</td>
</tr>
<tr>
<td>11-15 &quot; &quot; &quot;</td>
<td>4</td>
</tr>
<tr>
<td>16-20 &quot; &quot; &quot;</td>
<td>4</td>
</tr>
<tr>
<td>Over 21 &quot; &quot; &quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

on private study varied between none and over 21 hours (Table 14) and 64% reported doing very little study during the two vacations

The majority (56%) reported taking notes which were as full as possible. No clear group preference was indicated for formal teaching or working individually, though about a half (52%) reported learning more from lectures than from reading on their own.

Although about half (52%) reported playing games regularly, a minority (20%) reported that this took up more than 10 hours per week. As regards club or society activities, a large majority (68%) felt they were active members, the most active (20%) devoting over six hours per week to these activities.

Reading tastes varied widely; fiction (64%), classics (64%), science fiction (52%), philosophy/psychology (40%), politics (24%) being the most popular, the majority (52%) reporting that they read more than one book each week. Their reading of popular science journals was sparse, "New Scientist", however, was read at least occasionally by about half (52%).

They do not regularly go to the theatre, concerts or art galleries, though a minority (20%) go to concerts several times a term, even weekly.
Whilst at school, the majority (72%) claim to have thought of becoming an engineer, though the majority (60%) thought that a degree in Science was more likely to lead to the highest posts in industry and government service than one in Engineering, and an even larger majority (80%) thought that the engineer does not enjoy the same standing in society as a scientist. Nevertheless, they did not agree (76%) that the main function of a scientist was to pursue knowledge for its own sake regardless of any practical application.

8.53 Study habits questionnaire

31 of the questions were taken from Parlett's questionnaires in order to produce his syllabus-bound - syllabus-free scale diluted by other relevant items. In this, objectives were to determine whether a tendency to organise work around the given syllabus (syllabus-bound) was a factor in promoting success and to determine whether his results regarding Physics students were replicated in this sample in so far as they continued in the Physics department. As regards success, scores on this scale correlated significantly only with the first year Mathematics scores (r = 0.33; p < .05, 1-tailed), though a quarter of the students who were most 'syllabus-free' were very successful compared with 56% of the others (N.S.) and half of them failed at some stage, compared with 12% who had medium or high success (Fisher, p = .04).

The relationship with 'A' level performance, in contrast, is the direct reverse of this (r = -.31; p < .05, 1-tailed).

As regards choice of Physics, though the relationship was in the predicted direction, and the two highest 'syllabus-bound' students tested went into this department, it was not strong enough to be statistically significant. However, if the test is widened to include students entering the Mathematics department, the relationship does become significant (Mann-Whitney, p < .025, 1-tailed).

The corollary of this prediction does not, however, seem to be true in that of the six most syllabus-free students who
8.54 Further studies  A psychologist who assisted in much of the preliminary examination and organisation of the raw data also carried out experimental work with the students of one of the entries to the course. In relation to the syllabus-bound scale, students were given a shortened form of the questionnaire, modified to apply to study habits on previous courses, at the beginning of the course, and in their final term. She concluded that changes in the scores were understandable in terms of the success, experience and motivation of the students. For example, one student who left the course was the only one who shifted towards being syllabus-free and the student who moved most towards being syllabus-bound, was highly motivated and began the course with the most syllabus-free score. It follows that students can adopt syllabus-bound modes of study in practice, though this latter student did actually transfer to a science based subject outside the scheme.

Alongside this work, discussions with students revealed that though the majority felt that their thought processes were more flexible and their interests wider than before they started the course, they considered scientists to be less flexible in their thought processes, more dedicated to their work, and having a narrower range of interests than other people.

The possibility of an additional study, intended to probe the sensitive area involving stress to students in following the uncertainties of a 'switch to science', from an

† Thanks are due to Mrs. S. Hinton for this work and a considerable amount of additional work, some of which is reported above.
Service for a variety of reasons, was explored. However, in view of the complexity of the situation both regarding the large number of variables and the sensitivity of the investigated area, the study did not go beyond the preliminary investigation\textsuperscript{41} conducted entirely within the Health Service. Had it gone further, it would have been conducted and reported in such a way that the author would not have been able to identify any individual student, as all were known to him personally.

The Director's report is as follows:

"A very carefully planned and executed investigation would be needed to evaluate statistically any difference in the need or use of the University Health and Welfare Services by this group of students, as compared with the students accepted for the honours B.Sc. in (control) course.

The medical records of those students of both groups who used the University services in 1968 and 1969 (not all did), have been scrutinized by me and from this and my knowledge of the students themselves, I have gained the impression that they have a pattern more like those of the Social Science and Language students than the Pure and Applied Science students, which is what one would expect anyhow. The "Arts" group generally use the Health and Welfare Services more than the Pure and Applied Science students, though the sex ratio may have a bearing here.

It is my opinion, however, that students on this and any other new or experimental course should be expected to need more support, both academically and 'health-wise', and in fairness to them this should be made available before such courses commence."

\footnote{Thanks are due to the Director of the University Health Service, Dr. D. M. Martyn-Jones, for his support, and that of his staff, in the extensive work required in examining records and classifying them for analysis; and in particular for permission to quote a summary of the results.}
8.61 **Introduction** Although many studies have been reported in which correlations between 'A' level grades, intelligence test scores and University performance are examined, some studies indicate tacit acceptance of a certain sterility of argument. That is, in emphasising grades and questions about low and high correlations, particularly with 'A' level, attention is directed away from points where information is more difficult to gather and interpret but which is likely to be more important in relation to success. In addition, there seems little point in examining correlations between relatively unreliable (in the objective test sense) examination scores (e.g. a correlation of 0.4 between two examinations of separate reliability 0.8 implies that only 16% of the total variance is accounted for, i.e. 25% of the maximum accountable 64%). Thirdly, little predictive information is available from this type of analysis and finally, high correlation would imply that Universities were achieving no differently from schools, nor would University teachers wish to explain achievement in terms of that at school. Other studies, including this one, have attempted to study the factors involved in order to provide information which can be used to maximise both student performance on valid tests and the quality of courses regarding their utility, challenge, and emphasis on goals, particularly with respect to variety in the student population. In particular, this study has attempted to gather information about factors affecting student success in order to illuminate the problem of sixth form curriculum development (in indicating abilities which are required), and where strong factors emerge, in guiding students, selectors and teachers of the B courses.

8.62 **Predictive power of the first year examinations** In following the progress of the students, an important question has been raised by members of staff, i.e., what is an appropriate pass mark for the first year? The general
55% or more to indicate satisfactory performance is entirely borne out by the results. Thus, a strong relationship exists between first year examination results and second year performance. For example, 28% of those with less than 55% in their first year achieved less than a pass in the first term of PEMS, compared with 95% of those with more. At this stage, the median mark of students is the same as that of the 'regular' entry.

The position has been similar at the end of the two-term PEMS stage (22% c.f. 95%). However, of those 'failing', 30% have continued, but with lower than average performance. It follows that, though as yet no student has been successful with a first year mark of less than 40%, present practice is correct, though there is a 40% chance of a student in the 40-55% range in the first year of subsequently failing.

8.63 Entry qualifications in Science and Mathematics Another of the important questions to be answered about this course, relates to the success of students with respect to their prior experience and knowledge of Mathematics and Science.

In this respect, although students with more Mathematics and Science 'O' levels seem to do better in this course, no significant relationship exists between this factor and first year examination performance.

As regards the entry minimum of an 'O' level in Mathematics, a low grade in this subject seems to be no particular disadvantage. Though those who failed 'O' level Mathematics or received the lowest pass grade, scored significantly lower as a group on both the Numerical section of the AH6 and on the Mathematics preknowledge survey, this difference was reduced to non-significant levels by the end of the year in Mathematics; in spite of these students scoring lower (not significantly) in all three first year examinations. This difference disappears at the PEMS stage.
With regard to Science 'O' level entry, a strong relationship exists: 50% of those with no Science 'O' level achieved 40% or less in the first year. Compared with this, only 7% of those with one or two Science 'O' levels failed (Fisher; p = .0017). Similarly, as a group, the students with two Science 'O' levels are the most successful (Table 15).

Table 15

First year examination performance against number of Science 'O' levels

<table>
<thead>
<tr>
<th>FIRST YEAR MARK</th>
<th>NUMBER OF SCIENCE 'O' LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>&gt;57%</td>
<td>4</td>
</tr>
<tr>
<td>40% - 57%</td>
<td>2</td>
</tr>
<tr>
<td>≤40%</td>
<td>6</td>
</tr>
</tbody>
</table>

Setting entry requirements at one Mathematics 'O' level and one Science 'O' level, however, would have excluded two of the most successful pure Arts students. In addition, no student entering without Science 'O' levels has yet failed in the following years after having succeeded in the first year; indeed, this group tends to do disproportionately well. Thus, students with no Science 'O' levels find out in the first year whether or not they will succeed in Science, the majority of those failing going on to a Human Science degree course of some sort.

8.64 Science 'A' levels As might be expected, students with one or more Science 'A' level (including Mathematics subjects, Physics and Chemistry) scored significantly (p < 1%) higher
in the Mathematics preknowledge survey as well as in the first year Mathematics examination (p < 5%) and combined first year mark (p < 5%); but not significantly differently in AH5, Physics preknowledge (differences negative), first year Physics or Chemistry; this difference almost completely vanishing by PEMS. Indeed, a single Mathematics or Science 'A' level seems, rather than offering an advantage to students, to give a slight (but not statistically significant) disadvantage (1 : 3 failing compared with 1 : 4 of pure Arts students, and 1 : 6 of those with two relevant 'A' levels. In addition, 2 : 3 performed lower than average compared with 4 : 7 of pure Arts students and of those with two relevant 'A' levels).

8.65 Mathematics and Physics Preknowledge The Mathematics and Physics preknowledge surveys are the most important predictors of student performance, both having significant correlations with one or more first year marks. Of the two, Physics preknowledge seems to be somewhat more important, both for the whole group and, more significantly, for those students with Arts 'A' levels only: two thirds of the students with a score below the median on this test subsequently performed less well than average (i.e. compared with Science entry students), whereas only one quarter with high Physics preknowledge did so (Fisher test; p < .03). Further, the two students with lowest Physics preknowledge but who had success equal to or above the average (high success) had a Mathematics 'A' level: otherwise all 'high success' students were above the 57th percentile on this test.

Though the relationship with Mathematics preknowledge and success was in the same direction, it was not nearly so strong and not statistically significant.

However, a combination of the two tests yields interesting information. To date, of the 30 students in this sample, not one with low Mathematics and Physics preknowledge has done well, but only 2 out of 7 have failed; of those with high Mathematics and Physics preknowledge, the
passed than those with high Physics but low Mathematics preknowledge. The group with high Mathematics but low Physics preknowledge form a curious anomaly; three failing and two doing very well. See (Table 16).

Table 16
Success against Mathematics & Physics Preknowledge

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Above average</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>About average</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Below average</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fail (first year or later)</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

* high-low compared with median mark.

To illustrate the above, the student with (joint) highest preknowledge in Mathematics and the second highest preknowledge score in Physics received the highest ever first year Mathematics mark. This student had done Additional Mathematics at 'O' level, obtained below average Arts 'A' levels and having decided to join the course, returned to school to study Mathematics and Science for three months. The student subsequently chose Physics and has been successful to date.

Three possible reasons for the greater importance of Physics preknowledge are firstly, the Physics test had more
Mathematics first year examination had more complex questions than the Physics examination and gave a choice of questions, and thirdly, the Mathematics preknowledge survey had a ceiling which many students reached. That the underlying correlation for Mathematics may be somewhat higher is suggested by the observation that in one particular year the correlation between the marks on a more lengthy version of the test and first year examination marks was nearly 0.7 for the combined group of B students and others following the same course. In addition, there was a striking difference between the groups (weaker relationship for the B students). This can be seen as reflecting the students' perception of the importance of Mathematics in their course which derived from their observation of the attention given by staff to the problem of preknowledge both in the interview and in the follow-up of the remedial work. It also reflects the different treatments given by students of the two groups to this remedial work.

In an ideal situation, however, remedial work which provides essential required knowledge should not only reduce the correlations between preknowledge test scores and performance on the course, but reduce them to zero. In this case, in spite of the remedial work, there remains a strong residual correlation, of approximately the same magnitude as occurred in Physics, a subject in which no remedial work was set because it expressed no specific preknowledge requirement.

There are two possible explanations for this, one, that the view is simplistic, that a small number of pass-fail items cannot examine the fine detail of pre-requisites in terms of objectives which themselves involve a 'continuum', and two, that students' mathematical ability, as well as their knowledge, is expressed in their scores.

Nevertheless, the importance of Physics preknowledge suggests that although the complexity of the required learning in Physics and Chemistry is, perhaps, to a certain extent being overlooked by students and organisers alike, a knowledge
8.66 Mature students Though no statistically significant statements can be made about the success of older students, it is worth noting that a half of the students aged over 20½ have had high success compared with 22% of those younger. Since in addition, failure rates are slightly higher, there is a strong tendency for older students either to do well, or fail (Fisher, p = .07); younger students doing less well (p = .09) particularly the eighteen year olds (Fisher, p = .03), half of them, though successful, consistently performing below the average of their Science peers.

Table 17

Relationship between success and age at entry

<table>
<thead>
<tr>
<th>DEGREE OF SUCCESS</th>
<th>AGE TO THE NEAREST YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Above average</td>
<td>1</td>
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<tr>
<td>About average</td>
<td>2</td>
</tr>
<tr>
<td>Below average</td>
<td>8</td>
</tr>
<tr>
<td>Fail (first year or later)</td>
<td>5</td>
</tr>
</tbody>
</table>

8.67 Factors influencing high success Those students who were most successful (i.e. average or high performers compared with their Science peers (including two who left the course voluntarily) as a whole, scored more highly on AH5 Part I (verbal + numerical) (Mann-Whitney; p < .05), AH5 Part II (spatial) (p < .02), as well as AH5 combined (p < .01); had higher Physics preknowledge (Mann-Whitney, p < .02); tended to have higher Mathematics preknowledge (not significant).
In addition, though all first year examinations were very strongly related to success, they scored most significantly highly in Physics.

In contrast, for those failing the first year the only significant relationship existed for Physics preknowledge \((p < .02)\), Mathematics being the least important of the first year examinations.

For the pure Arts group alone (not including those with an 'A' level in Mathematics or Physical Sciences) the only significant factor is Physics preknowledge \((p < .02)\), AH5 verbal + numerical differences being not quite significant.

However, there was a strong tendency to a non-linear relationship between 'intelligence' test scores and success, both failing and high success students scoring more highly than those who were below average.

In a similar way, the most successful students were those with a low \((\leq 4)\) or high \((\geq 9)\) number of 'O' levels (these have a 65\% chance of exceeding the median first year score and hence have a high chance of success in later stages; the position is exactly reversed for the rest) \((\text{Fisher; } p < .05)\). The situation is the same for those with a high \((\geq 9)\) or a low \((\leq 5)\) A level aggregate score \((E = 1 \text{ etc})\). This suggests that the course was most successful with the students for whom it was designed, viz, those who performed badly at Arts because it was the wrong choice, and those who, in spite of doing well at Arts, decided that Science was a better option. Students whose 'A' level performance was just below University entrance standard for non-Science courses, have a much higher chance (40\%) of not finding success in this course.
9.1 Other Science and Technology courses offered in the United Kingdom

A search in the Compendium of University Entrance Requirements (CUER) and contact with University Registries and departments, have yielded a considerable amount of information on courses which allow students with Arts or Social Science 'A' levels (or otherwise unspecified 'A' level subjects) to read science or technology. These are listed in Tables 18 to 21, together with known polytechnic courses (not, however, included are the well known possibilities in medicine, or dentistry).

In some cases, studies in mathematics or science beyond 'O' level are very much preferred, in other cases there is a definite reluctance to consider any but the exceptional candidate, indeed for one University, the views of admissions officers are at variance with those expressed by registrars and in the prospectus - in these cases it may have been that admission officers had no experience of students using the preliminary year.

Spokesmen of other University departments, however, whilst confirming the theoretical possibility of transfer to their courses, put the likelihood of acceptance as low as "At the moment we are filling our quota of students from people who take Mathematics and Physics at 'A' level, and we have been in no great difficulty in obtaining people of the required standard". (In one case, 260 applicants for 15 places, in others 700 for 40; 900 for 30; 400 for 20).

The majority of these courses have had few, if any, students with qualifications entirely on the Arts side, mainly because of the very small number of students coming forward. Apart from the Biological Sciences, where many students follow courses for medicine, dentistry, agricultural and veterinary sciences from the Arts side, Geology (about one student per
### Honours degrees in Mathematics and Physical Sciences

<table>
<thead>
<tr>
<th>Institution</th>
<th>No. of yrs</th>
<th>CUER</th>
<th>Other remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Belfast</td>
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<td>70</td>
<td>BA, Maths &amp; Hist. &amp; Phil. of Sc.</td>
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<tr>
<td>Edinburgh</td>
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<td>79</td>
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<td>9</td>
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<tr>
<td>Lancaster</td>
<td>3*</td>
<td>86</td>
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</tr>
<tr>
<td>Leeds</td>
<td>4*+</td>
<td></td>
<td>Maths; Statistics; Comp. Sc.</td>
</tr>
<tr>
<td>North Staffs Poly.</td>
<td>4*</td>
<td></td>
<td>Computing Science</td>
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<tr>
<td>Nottingham</td>
<td>4</td>
<td></td>
<td>also J.H. w. Chem, Econ Geog, Phil,Phys,Psych.</td>
</tr>
<tr>
<td>Surrey</td>
<td>4 or 5*</td>
<td></td>
<td>poss. exceptionally, after I.S. year</td>
</tr>
<tr>
<td>Swansea</td>
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<td>28</td>
<td>B.Tech. Computer Technology</td>
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<tr>
<td>Bedford</td>
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<td>J.H. with Geol.</td>
</tr>
<tr>
<td>Cardiff</td>
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<td>31</td>
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<td>31</td>
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<td>31</td>
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### Honours degrees in Mathematics and Physical Sciences

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<th>Institution</th>
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<th>Other remarks</th>
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<td>26</td>
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<tr>
<td>York</td>
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<tr>
<td>Physical Sciences</td>
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</tr>
<tr>
<td>Surrey</td>
<td>4 or 5(^x)</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

\(^\d\) B.Sc. except where stated

\(^*\) 1 Maths 'A' level preferred, or generally expected

\(^x\) with Industrial year

\(\text{J.H.} \) Joint Honours

\(\d\) Might be possible with additional Maths 'O' level

\(\text{**N.B.} \) Many Universities are prepared to accept candidates with one Maths 'A' level + Arts subjects, where two Maths 'A' levels are preferred
### Honours degrees in Biological and Earth Sciences

<table>
<thead>
<tr>
<th>Institution</th>
<th>No. of yrs</th>
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<td>-</td>
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also J.H. w. Chem,Geog, Phys

### Environmental Sciences

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* Industrial matriculation, i.e., not direct from arts sixth.
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### Agriculture and Food Sciences

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<tr>
<td>Surrey</td>
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### Other courses

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<td>93</td>
<td>General with Honours</td>
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<td>Durham</td>
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<td>4</td>
<td>-</td>
<td>Ordinary Degree in Pure Science as J.H. already listed</td>
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* Industrial Matriculation
Even for Geology, which might be expected to attract students with Geography 'A' levels and arts subjects, few students apply. For example "We reserve the option of admitting clearly very bright students, but we have had a negligible number over the past ten years. Ten to twenty years ago we did have a few students who managed to do rather well, starting with a completely arts background, but it is interesting that they have all, to my knowledge, gone into fields of administration, journalism or public service." The combination of 'A' level Geography and Geology (treated here as a science), exempting students from the preliminary year, does however mean that students have inadequate knowledge of the basic science. For another course, "the main criterion is whether an applicant has the personal qualities that make him worth educating for another three years" and "If they are good, they manage alright - after all, a student with A's and B's in three arts subjects can tackle anything, if he is keen enough ....". In another "because we operate a very stringent selection among those arts students who wish to pursue Geology, we find that the few we have taken have proved themselves and have been willing to do the extra work necessary to make up some of their deficiencies".

The position of the applied sciences is even more extreme, for example "We always are willing to consider a few suitable carefully selected arts based students for admission to our preliminary year. However, in recent years the number of students coming forward has been negligible. Twelve years or so ago we made a special point of trying to attract people of this kind, but the enterprise was not very successful ...." In another University, where the requirement is one 'A' level in Mathematics plus arts 'A' levels, no students have come forward. (N.B. The possibilities in Science and Engineering for students with this combination are rather greater than for those given in the lists in Tables 18-21).
It is clear from this search that a few universities offer a wide range of opportunities. These are the Universities of Cardiff, Keele, Newcastle, Nottingham, Surrey and Swansea. The departments of Cardiff, Keele, Lanchester have been kind enough to allow extensive discussion of their courses and have also very kindly allowed information about the success of those students with arts 'A' levels who have followed these courses to be studied.

9.2 Notes on some of these courses

9.21 Cardiff preliminary year  Cardiff accept two or three students each year with 'A' levels entirely on the arts side, who have gone on to engineering and science courses (this does not include dentistry students). These are accepted into the preliminary year, which is designed for those students who for one reason or another have not satisfied departmental entry requirements for Part I of the normal three year degree courses. Thus students may be required to study subjects they did not offer at school or in which they did not achieve an adequate standard, e.g. mathematics for physical science and engineering, chemistry for biological sciences and geology. The courses are very similar in content to the Surrey courses, though there are differences in mathematics, e.g. applied mathematics at Cardiff includes numerical analysis and Boolean algebra, whilst the pure mathematics includes more extensive matrix theory. The "conversion" students have special tutorials which help them with their particular problems of language. Success would appear to depend on student interest and work in the same way as at Surrey.

9.22 Keele Transfer courses  At Keele, the three departments of Mathematics, Physics and Chemistry offer transfer courses which exempt students from a part of their foundation year course (i.e. one sessional and two terminal courses are remitted). Although theoretically a student at Keele could choose any principal subject irrespective of 'A' level, this does not tend to happen in these particular subjects ('A' level or the transfer course is required for Honours however). Since too, students study two principal subjects, the separate transfer courses are a little less extensive than in Cardiff and Surrey.
(each of the other institutions offer half the subjects offered at Keele). Thus students study (for physics) a course remarkably like those at Surrey and Cardiff in content, the mathematics being brought in where necessary (several of these students have had mathematics 'A' level). The students generally enrol for the courses after they arrive at Keele and the small numbers (1 - 5 in Physics, average about 2) are catered for on a tutorial basis with work matching individual need.

Similar remarks can be made of the mathematics and chemistry courses. Not all students have continued with their transfer subject at principal level, and it is clear that the integrated first year followed by a wide range of course combination allows those who find that their transfer subject was not after all the best choice, to continue without prejudice (full remission may not in any case have been taken).

9.23 Lanchester The Lanchester General Engineering B.Sc., is quite different from the others; thirty to forty students have started this course since 1969 and the range of 'A' levels is similar to the Surrey intake, including in addition students who have been unsuccessful in a science 'A' level. The students spend a little over half their course time on the mathematics and physical sciences component of Part I (42 teaching weeks), the content of which is very similar to the Surrey course. The practical work, however, is radically different, involving more than one department, presenting an engineering approach to experimentation with novel and interesting experiments. The success of this course is reported elsewhere.

9.24 Newcastle Although Newcastle University undoubtedly offers the widest range of four year courses into which students with arts 'A' levels may enter, almost all such students follow subjects in the preliminary year as a preparation for dentistry and agricultural subjects. Some, however, follow one or other of the complex range of possibilities for single, joint or general honours. This
interest, needs and abilities to course which seems to be especially important for arts students changing to science.

The three year Engineering and Arts studies course offered since 1967 by the department of Mechanical Engineering, is in a very different class, as it aims "to provide an entry into the engineering profession for students with 'A' levels in arts ... and to provide an honours degree course in engineering which is much broader in concept and scope than the highly specialised courses presently available". Arts courses are selected from Sociology, Psychology, Economics, Economic Geography, Law, Industrial Relations, and account for about a third of the course. In addition, "In anticipation of the future needs of engineers, all candidates are required to become proficient in the use of a modern European language". The proportion of arts students following this course, has, however, been small, the total number being in single figures.

9.25 Warwick The Management Sciences course caters for students without an 'A' level in mathematics in a quite different way to the other courses discussed. Such students (one in six so far) are required to revise 'O' level algebra and attend a residential course for three weeks before the main course to cover (in the main) essential elements of algebra and calculus. As in other courses, a high proportion of these students have transferred to Philosophy, Economics, Medicine or History.

9.26 North Staffordshire This polytechnic offers a B.Sc. Computing Science course which caters specifically for those who have not studied mathematical subjects at 'A' level, as well as those who have. It provides "two alternative streams ... one having a strong mathematical bias, and the other treating alternative subjects to a comparable depth." ... The aim of this course, in the first two years, is to provide students with a wide basic knowledge of the fields of automatic computation and data processing. During this time, the students undertake a full practical training in the scientific and commercial applications of computing and they
students spend their third year in an approved computing environment". The principle purpose of the degree is to fill the need for graduates to become Systems Analysts, Senior Programmers and Systems Designers for which "the demand far outranks the supply" ....

So far, 15% (i.e. 92) of the entry (1966-1972) have had Arts 'A' levels only, and a further 20% had Mathematics in addition. Of the graduates, the arts students, whilst having a significantly higher success rate (88%; Fisher, p = .033) have achieved on the whole, lower classes than those with Mathematics or Science (p = .0013). Recent course changes have redressed this balance.

9.27 Other courses Disappointment has been expressed in other Universities at the small response to courses which accept arts students. The York chemistry transfer course, and the Aberystwyth ordinary degree course have had few applicants from such students.

Although there are no specific courses for arts students in science and engineering in the University of London, the introductory course scheme makes this theoretically possible, though it does not seem to happen. At Bedford College, though, "there has been one case of a sixth form geographer with science 'O' levels completing some advanced courses in chemistry by (this) method. It is common for geographers to continue with geology (and sometimes biology) after taking (their) introductory courses". These will, however, be taken in the course of a normal three year degree.

The City of Bath Technical College, in collaboration with Bath University of Technology and Bath Colleges of Education, offered a quite different approach in providing a one year "Science Orientation Course", successful students satisfying the entry conditions for B.Sc. and B.Ed. courses. It was described as an arts-to-science conversion course though it is noted too that there is increasing demand for scientists, science teachers and engineers with a good arts background. Sadly, though there was a lot of interest in the course, there were insufficient applicants to offer the course, with the problem of grants seemingly a contributory factor.
U.M.I.S.I., the Faculty of Technology of the University of Manchester, has a preparatory year course used by a majority of the departments for students who are "insufficiently qualified to commence in the Honours degree course" whilst being "able to satisfy matriculation requirements". A small number of students with predominantly arts qualifications entered this course in 1970, though, like many of the other preliminary year courses it also caters for overseas students.

Nottingham University, too, has a preliminary year in which "one or two students have been successful during the past few years". On the applied science side, students without the normal science qualifications may be considered only after industrial matriculation, i.e. a period in industry involving work relevant to the selected course of study.

Reading University offers a preliminary year, primarily designed for arts students and others who do not have the correct subjects at 'A' level, who wish to study in the Biological Sciences. This, too, has attracted only two or three students from the arts side.

Bradford University has recently introduced a course in Industrial Technology and Management, as "the first of a series of such courses where the proportion of science and technology and social sciences varies according to the objectives and future function in society". These objectives are related to changing patterns in basic producing industries and services and the demand for general abilities encompassing management sciences and a wide range of technological studies. No details are known about arts students entering this very new course.

9.3 Teachers' awareness of these courses
9.3.1 Data collection
In discussing the need for such courses as well as the possibilities that the Surrey course might be transferable to other Universities, a number of factors need to be taken
awareness of such courses; their attitudes towards such changes, the problems of University entry, particularly the competition for places in certain subjects; and students' changing attitudes to their chosen subjects.

Accordingly, a questionnaire was designed and sent to seventy-six teachers who attended the 1970 CRAC conference many of whom had been contacted personally at the conference. These teachers might be expected to be more aware than average, particularly of the Surrey course, as a previous CRAC conference at Surrey had been attended by a few members who heard Professor Elton speak of this course.

Similarly, the National Association of Careers Teachers kindly allowed a slightly revised form of this questionnaire to be sent to four hundred of its members with interests in Universities and Polytechnics.

These questionnaires were sent out before the publicity associated with the first Surrey Physics B graduates in July 1971.

Thus it was hypothesised that the very small number of students applying for these courses was due in part to careers teachers being unaware of such courses, through the enormous pressure on them in their work, the vast number of University and Polytechnic and College courses available to students and the large range of other careers opportunities, as well as the difficulty in retrieving the appropriate information from some prospectuses.

The questionnaire, (revised version shown in Appendix 5) asked about awareness of eleven courses and asked for known courses to be named. Thus two levels of awareness were probed:

(i) a low level involving at least a dim recall that a particular course had been mentioned before.

(ii) a high level, involving the ability to state the names of such courses from memory.
It also asked for careers teachers' knowledge of students following such courses, their opinions about students changing from arts to science, particularly in relation to their success on the arts side.

The response to the first questionnaire was 35 out of 76, and to the second 78 out of about 400, many of those circulated being in schools without a sixth form.

9.32 Knowledge of courses 89% of teachers reported that they were aware of the possibility that students with arts or social science 'A' levels could embark upon a science or technology degree. Given a list of specific courses, those of which teachers were most aware were:

1. Those at Keele (65%)
2. Lanchester, B.Sc. Engineering (50%)
3. North Staffs B.Sc. Computing Science (42%)
4. Surrey Physics B (40%)
5. UMIST Preparatory year (40%)

The least well known were:

1. Surrey Biochemistry B (24%)
2. Surrey Metallurgy B (27%)
3. U.L. Introductory Courses (27%)
4. Surrey Physical Sciences (27%)
5. Birmingham Preliminary year (31%)

The least well known course gives evidence of a response set in the questionnaire as it did not exist at the time the questionnaire was given, at worst it sets a level below which (on average) teachers were not prepared to admit lack of awareness. Nevertheless, about half the teachers reported being aware of five or more of those listed.

Differences in the composition of the two samples of teachers (not known for those attending the CRAC conference)
of four of these courses: the Polytechnic courses were known by 25% more of the NACT members (whose types of schools may better reflect the National distribution) whereas the York and Keele transfer courses were known by 17% more of those attending the CRAC conference. In addition, 10% of the teachers knew former students who had followed one or other of the courses. This, if extrapolated to the 3000 or more schools in the country offering 'A' level subjects suggests that ~300 students have followed such courses. This, though slightly high, is a close estimate of the number of students known to have followed the courses attracting the most arts students.

Since the teachers sampled might be expected to be on the whole better informed than the average teacher, whether specialising in careers or not, the figures must be considered as upper limits. Nevertheless, they give grounds for believing that a significantly large proportion of careers teachers are indeed aware of the possibility of transfer to science and technology.

9.33 Attitude to transfer Not counting schools with a small University entry (0 - 10 p.a.) 75% of the teachers thought that students studying mainly arts and social science 'A' levels should be encouraged to consider applying for one of the listed courses. This increased with size of sixth form and University entry from the school (p < .02). In addition, this proportion increased with the number of courses known. It was highest for teachers from comprehensive schools (21/25) and lowest for teachers from Public schools (2/4). A slight difference is noted between Arts teachers and others, though a majority (72%) were in favour, more (78%) Science and Social Science teachers were in favour. However, teachers favoured this encouragement more for students who were doing well in their subjects (though the evidence that this may be right is conflicting.†

† this report gives evidence against this view.
Nearly half (47%) of teachers thought that one or other former students might have been interested or well advised to consider such a transfer, a majority of these (35% of the total), knowing of students who had been doing well in their subjects to whom this applied. A quarter (26%) thought they might have students who were currently about to take 'A' levels who might consider the courses seriously. This agrees with teachers' overall estimate that the average sixth form would produce about 0.4 students per year for such courses (for this purpose 'very rarely' is taken as one every ten years, and 'once every few years' as one every four years). This figure, if extrapolated nationally, would suggest over 1000 arts and social science students would apply annually for these courses. Even if a correction is made for teachers not responding to the questionnaire (assuming they did not know of these courses) and teachers understandable reluctance to inform arts students doing well of the possibility of considering transfer, ~200 should emerge. This suggests that in general, these students do not know of such possibilities, or are not willing to consider them. This is confirmed by the fact that, subsequent to the questionnaire, from an examination of the schools from which students entered three of the courses (these returns accounting for about half the total of students) four students came from the 75 schools surveyed. This is equivalent to about 10% of schools having careers teachers having the information producing one student each. This suggests that about 300 students should emerge annually, if all teachers were equally well informed, confirming the above estimate. In addition, though teachers were on average aware of nearly half the courses listed, students accepted on these courses who knew of any of the others were in a very small minority.

9.34 Other information from the questionnaire Although the majority (57%) thought that the proportion of sixth formers studying arts and social science was about right, arts teachers were slightly more definite (62%) – in
The majority of teachers (71%) thought that when selecting 'A' levels students had in mind a particular University subject; science teachers, however, were more definite (84%) suggesting that they were influenced more by their own students. The majority (82%) thought that students were on the whole aware of the high degree of competition for places in Universities for certain subjects. This was qualified by several teachers who stated most strongly "Because I tell them" or "I tell them, we tell them - often".

Though virtually all schools allowed mathematics (96%) and biological sciences (88%) to be taken with arts subjects, only half (51%) allowed the physical sciences to be mixed with the arts.

Though 90% of teachers thought that, in practice, a Science or Technology degree is more vocational than an Arts degree, 67% thought it had as great a general educational merit as an Arts degree, scientists being slightly more definite (76%).

Many teachers stress that given proper careers advice, there should be little need for such courses, "ample opportunities exist for girls as well as boys to study science in the sixth" or "if the advice is adequate the applicants would come from those who neglected good advice or from the rare few who developed an aptitude very late"; another "Employment position of graduates in Industry at the moment does not encourage the change"; also "I would expect ...... a candidate to have proved his merit by good 'A' level arts passes ...... in my experience here the good candidates have no wish to change" - this from a teacher from whose school came one of the 1970 Physics B students.

Teachers, from their comments, feel that the initiative should come from students, stemming from real interest and not from a perception of the "market value" of a science or technology degree in which case these students will have already chosen science. Several feel that in their experience
In fact "the choice of arts 'A' levels seems to entail .... an inbuilt aversion to the sciences". (In fact one teacher quoted a student with three good 'A' levels in science, who started a Physics degree but after six months changed to English - now having an honours degree! However, the converse does also happen - at the same time as the first students of the Surrey course graduated, a History graduate also received a first class honours degree in Physics!) Some point out that possibilities for change exist and are taken advantage of during a student's sixth form course. In considering the problem of potential failures, another asked, "if the failure rate is high, is there a 'safety net'?" This is a crucial issue for these courses. At York, no student is accepted unless another arts or Social Science department is prepared to accept him if things do not work out. At Keele, there is a built in safety feature, but in addition, some students have not in fact used the exception procedure, keeping up their studies in the sessional and terminal courses.

One teacher, noting that "now that the shortfall in certain science subjects has been cured .... we may need in the future, not more conversion courses, but more broadbased arts/social sciences/pure science and technology courses leading to more informed industrial management" - an opinion confirmed by others. On the other hand, many teachers commented favourably on the whole idea of arts - science transfer confirming in principle their agreement with the usefulness of the concept.
10.1 Implications for the sixth form curriculum

Recent discussions about the nature of the sixth form curriculum have raised questions about an appropriate selection of knowledge, particularly as regards University entry. In this, the introductory science year has shown that a selection, geared specifically to University physical science and engineering, can be made which gives an adequate preparation for those courses. In addition, some of the methods used, e.g. Keller plan, simulations, films, self-teaching experiments, programmed tests, structured work sheets, most of which are being used increasingly in schools in any case, are likely to be effective.

However, this cannot be central to any discussion of the development of a curriculum in which a wider range of subjects is studied by students than hitherto. In this, a very different pattern of subjects should ultimately emerge, subjects for the non-specialist being liberal in conception and thought out in a radical way, developed with all modern resources and understanding of the process of curriculum development, in which the emerging solutions might well prepare the specialist better.

In principle, in the development of any curriculum, the general aims should be established by a representative sample of the population (including parents) who would consider the values and hopes of their society and the needs and aspirations of the pupils, giving due weight to any reports on the subject. As the needs of the learner should take a central position throughout, this suggests that the learner's role, at the very least, in the selection of his curriculum, should increase with maturity. In addition, consensus views of aims must make due allowance for minorities, religious, national and cultural, objectivity being established when more than one member of the 'Aims Committee' agree with a particular
almost entirely in the hands of educationists leaves much to be desired, as the necessary judgements require a much broader expertise than is usually present. Nor should one view predominate, for example, it has been suggested that middle-class teachers have no right to set aims and objectives for working-class children; this argument has validity in a much wider context, as education is about values as well as understandings and skills.

Whilst greater weight of view would be reasonably given to educational thinkers, for higher, more specialised education, increased weight must be given to the views of employers, and to the need to select knowledge and skills required in the subsequent stages of a student's career or study rather than that which is of intrinsic general value to the student or to society.

In the case of the Introductory Science year, the principal aim is to train scientists and engineers, which includes providing understanding of an adequate body of knowledge and a suitable range of skills so that the student can continue with profit. It follows that the course will, as such, not be transferable to the sixth form, since this group will be in a minority.

Hence, courses developed for the majority will be geared to a general education in science. That this might be of general benefit to future scientists can be seen from the treatment given to topics in the Nuffield Secondary Science Project, which if extended for the more able, would provide a very sound education indeed for the future scientist and engineer. In such courses, motivation and interest would play a much more important part in the selection of approaches to material than hitherto. This would include tapping current interests in class and allowing temporary curiosity to develop into "honest, valuable and exciting experiences in scientific education" rather than fulfilling a need to cover items in a syllabus for example "leading them to the successful (but by now uninteresting) conclusion that air displaces volume"
Broadening the scope of teaching to allow for exploitation of class interest can lead to scientific and mathematical development is widely recognised\(^5\), even in courses for scientists, where syllabus coverage may seem to have intrinsic merit. In this, the pyramidal approach, with the 'apex' (i.e. the large unifying ideas) at the end of the course, present even in modern approaches, may postpone and even stifle\(^\dagger\) natural interest in that important human study, the sciences. On the other hand, in a two level course, such as N/F or Q & F, with restricted second-level choice, postponement of final choices by a year would be possible even if second-level courses were more specialised. In this, the selection of a common core of knowledge would make it unnecessary for changes in University courses to occur, which in any case should always be a secondary consideration to planning for educational objectives. On the other hand, if second-level courses are to give students such knowledge and understanding of subject matter as is required for University entry, then the syllabus content of the University of Surrey Introductory Year is very relevant to this, particularly as courses in other Universities of comparable nature have a very similar content. This suggests that in reality, University teachers in the Sciences are agreed on a reduced core of knowledge which, if mastered, is highly acceptable for entry to existing degree courses.

### 10.2 General conclusions

It is becoming increasingly recognised that the principle of a broader curriculum is as relevant to tertiary as to secondary education in Science. The wider range of jobs\(^5\) sought by graduate scientists and technologists and the need for this, has led many to advocate and initiate more broadly based University courses (e.g. the Surrey Human and Physical Sciences and the Manchester Liberal Studies in Science, amongst others not previously discussed in this report.). Indeed, the view that "if Universities concentrated their attention on educational objectives, then vocational requirements would be met" has been expressed\(^5\). Such views have been

\(^\dagger\) the reverse approach, the "upside-down pyramid" has been suggested as a better one, even by Introductory year students.
example: "I question whether this (i.e. attempting to develop an equivalence to a science entry after an Introductory year) is the best thing to do" .... (alongside concentrated formal topics) technological studies "such as basic mechanical and construction engineering design (etc.) from a technology/economics viewpoint and topics such as pollution and bio-engineering might be appropriate" .... "I feel that the student with the arts background could be much more appreciative of this approach than the more specialised scientist, and this would ultimately lead to a broader grasp of the technology than we presently achieve."

However, the courses with these characteristics, and the more traditional courses, are not attracting arts students in large numbers - indeed there is a shortfall of an order of magnitude between this and teachers' estimates of the actual number (rather than any idealised potential number). This suggests that factors outside the control of specific courses have been too influential in controlling applications for them. For example, the recent publicity about increasing employment difficulties of graduates overlooked the fact that scientists and technologists as a whole are still (though marginally now) more quickly employed than arts graduates. It also made the assumption that they should be employed primarily in their own field in contrast to arts and social science graduates.

These recent changes in the employment patterns of science graduates have led to questions about the value of the switch courses. However, in view of the rather small number of these students following any one course, and the tendency for them to wish to teach or otherwise not be employed as scientists, this does not seem to be a serious reservation. Also, it would seem reasonable to consider a science or engineering degree as just as valid a preparation for many careers as the more traditional arts degrees - in which case the graduates of the B courses might well have an advantage in view of their arts background.
courses in view of the likely development in the sixth form, as there have not been these developments (though there is evidence of a swing to science in the Comprehensive schools)\(^5\), this course has been prematurely terminated by outside influences. These courses have, however, fulfilled an important role. When a student who 'dropped science along with others in a 'B' Grammar stream often, on reflection, regretted (this) mistake because (my) interests were in fact on the science side (having) more interest in practical work and study with practical applications rather than on the arts side" and "took special courses in Modern Science, Logic and Computer Programming" and "having started on this course it never seemed practicable thereafter to make a change" could take this opportunity an important purpose was served.

Nevertheless, any course can last only as long as the perceived needs survive and so long as students have a choice of course. However, a real choice exists for students only if they have adequate knowledge of all alternatives open, and it seems that the small proportion of potential applicants coming forward is due to general lack of awareness on the part of sixth formers, both of the existence of these courses and of the success of many students in following them, in addition to other factors mentioned.

Another factor is that, at present, students as a whole seem to be re-evaluating the idea of a University education, which together with an increase in the clearing rate of arts applicants, may have led to a reduction in applications for the 'B' courses to such an extent that it cannot be mounted in 1973. The reduction was seen in 1971, but could not be confirmed in view of special conditions at the time. In 1972, the reduction in applications around U.C.C.A. clearing time, together with the withdrawal of four students, led to a repetition of the same situation. [Three of these students were mature and withdrew for non-academic reasons, mainly financial; the fourth transferred to Human Sciences.]
emerged, two of these were for Biochemistry which was not being offered in 1973 (p.51). This left only two suitable applicants and, on the expectation that the difficulty of getting suitable candidates from the late applications would be repeated, the decision not to offer the course in 1973 was taken.

That a course, started on educational grounds was curtailed on economic grounds, implies that in the University of Surrey belief in the validity of these educational arguments which includes the question of the success of the students, is of inadequate force against an economic argument not widely applied in Universities. However, the course had in reality been maintained only by repeated advertisement, e.g. in the national press, at considerable cost to the University and as a special exception to its normal practice of not advertising courses. This, coupled with occasional articles in Further Education, the daily newspapers and The Times Educational Supplement, had proved insufficient to tap the potential demand for the course. Alternative means might have been to approach the schools directly (judged inefficient) or to publish in, say, New Sixth. In the opinion of the author, such measures should have been taken before the final decision was made. Longer term measures could include a classified section on courses with unusual entrance requirements in the Compendium of University Entrance Requirements, or a publication, perhaps by the Schools Council, about such courses and about others which cross traditional subject boundaries, whether in University or Polytechnic. Such a publication might be financed by contributions from each institution mentioned.

In conclusion, these courses have been successful in providing an opportunity for students with arts backgrounds to study science and engineering; the students are successful in making the "transfer" (though marginally for a minority); and although at the present time students tend to consolidate their relatively early subject choices in school and the courses have never been overwhelmed by suitable applications,
additions to the range of possibilities available to the sixth former and to the potential University graduate in work. Thus, they should be given serious consideration by any student in the arts sixth who may be wondering whether he or she has taken the right decision in being on the arts side.


PHILIPS, CELIA M., Some changes in the factors affecting University Entry (unpublished) 1969.


2. DAINTON, F.S., op cit (1)


DAWS, P.P., Paper at same Conference.

see also


also

PARLETT, M., and HAMILTON, D. "Education as Illumination; a new approach to a study of Innovatory programmes". Occasional paper; Centre for Research in Educational Sciences, University of Edinburgh, October 1972.


BLOOM, B., "Learning for Mastery", UCCLA. CSEIP. Evaluation Comment, May 1968, 1, 1


Instructional Objectives Exchange Project., Centre for the Study of Evaluation, U.C.L.A.

EISS, A.F.,

STAKE, R.E.,
Language, Rationality and Assessment in W.H. Beatty (ed) op cit (29).

10 for example

SC5/13
'With Objectives in Mind', Macdonald Educational 1972.

HARLEN, WYNNE,

A.A.A.S.,
Science - A Process Approach, e.g.,

WALBESSER, H.H.,

see also

The assessment of attainment in sixth-form science, Appendix J to SC 70/293.

NUFFIELD FOUNDATION,

FERGUSON, G.A.,

SIEGEL, S.,

BRADLEY, JAMES, V.

13 Surrey Physics degree., Booklet for students, from the department.

MCKEACHIE, W.J.,

GAGNE, R.,

This technique is widely used in schools and in particular Nuffield Secondary Science, op. cit. (10).


See, for example., 'The Production and use of single concept films in Physics Teaching', Commission on College Physics 1967.

KILTY, J.M.,

TABER, J.I.,
Learning and Programmed Instruction, Addison Wesley 1965.

e.g. MAGER, R.F.,
op cit (9)

LEITH, G.O.M.,

On the use of constructed response questions in programmed learning, see e.g.

CALVIN, A.D. (ed);

NUFFIELD FOUNDATION,
Guide II op cit (17)

GAGNÉ, R.M.,
The flexible, modular approach is discussed in:


GAGNE, R.M., Learning Heirarchies, op cit (25)

TABER et al., op cit (20)

HEIM, A.W., Manual for the Group Test of High Grade Intelligence, AH5, N.F.E.R.


and e.g.,

GAGNE, R.M., Learning Heirarchies, op. cit. (25)


KELLER, F., op cit (5)
It has been pointed out that when Briggs first constructed logarithms in 1624, he worked out
\[10^{\frac{1}{2}}, 10^{\frac{2}{3}} \ldots 10^{\left(\frac{1}{5}\right)}\]
by extracting successive square roots 54 times to 32 decimal places.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Jones, C.L. and McPherson, A.F.</td>
<td>After Highers, TES (Scotland), May, June 1972. (reprint of 6 articles from Dept. of Sociology, University of Edinburgh).</td>
</tr>
<tr>
<td>Doe, R.F.</td>
<td>in internal reports, University of Surrey.</td>
</tr>
</tbody>
</table>


op. cit. (1)


SCHOOLS COUNCIL, Sixth form Curricula & Examinations SC/WP5 HMSO 1966.

SCHOOLS COUNCIL, Science in the Sixth Form. SC/WP4 HMSO 1966.


NEWSOM, Report, 'Half our Future', H.M.S.O., 1963. was used as the starting point for the Nuffield Secondary Science Project to the N.W. Regional Project, amongst others.

In panel discussions of the N.W. Project.


WILLOUGHBY, S.S., in Michael W.B. (ed), op. cit. (50).

T.E.S. 9/6/72. "Science graduates seek wider range of jobs".

<table>
<thead>
<tr>
<th>Reference</th>
<th>Author(s)</th>
<th>Title</th>
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<tbody>
<tr>
<td>55</td>
<td>NEAVE, G.</td>
<td>Swing to Science in the Comprehensives, T.H.E.S., 15 August 1972.</td>
</tr>
<tr>
<td>60</td>
<td>VAUGHAN, B.</td>
<td>Network Analysis in Primary School Mathematics, Science Teacher, December 1971, p.32.</td>
</tr>
<tr>
<td>61</td>
<td>PARLETT, M.</td>
<td>op. cit. (8)</td>
</tr>
<tr>
<td>63</td>
<td>BAGNALL, N.</td>
<td>Arts students top in Science, Sunday Telegraph, 18.7.71.</td>
</tr>
<tr>
<td>64</td>
<td>KILTY, J.M.</td>
<td>Reduced Sciences Courses as a preparation for Normal University Honours Course in Science: Final Report to Schools Council. I.E.T., University of Surrey, April 1973 (unpublished)</td>
</tr>
</tbody>
</table>
In addition to specific acknowledgements in the text, sincere thanks are due to members of the Institute for Educational Technology for their support and help at all stages of the project, in particular, Professor L.R.B. Elton and Mr. S. O'Connell, to Mr. D. Birch and Mrs. E. Branson (then student associates) and Mrs. S. Hinton for much statistical work; to course lecturers for their help, especially Mr. R. Scobie, Dr. R. Taylor, Dr. D. Allam, Dr. P. Doidge, Dr. A. Clough, who allowed observations of their teaching, and Mr. D. Boud, who also carried out some experimental work; to other members of staff of several departments in the University of Surrey; to those responsible for other 'arts to science' courses who gave much time in discussion; to school science teachers and their students who co-operated in testing; to careers teachers who answered a questionnaire; to the Schools Council for the grant; to all the students without whose help, support and consideration this work would not have been possible.

Sincere thanks are also due, for their secretarial help at various stages of the project, to Mrs. J. Thackwray, Mrs. L. Hamblin, and to Mrs. G. Stevens who typed the final report.
Part III is presented in four chapters, being a reorganisation of the two
project reports to the UGC (1, 2). These are summarised below.

11. The course was one of three courses for tertiary teachers and
concentrated on new and less experienced teachers (11.1).

   Its aim was to introduce lecturers in mathematics, science and
engineering to the teaching side of their work. This was achieved
through lectures, displays and group discussions in a number of topics,
practice lectures and educational aids workshops (11.21).

   The course was evaluated by participants through daily returns
and a terminal questionnaire (11.22). It emerged that the participants
perceived that the course was about values and attitudes as well as
about knowledge and skills and the most useful part of the course was
seen to be the group work.

   In 1973 two courses were offered, one for teachers with substantial
experience (11.31) and one modelled on previous courses for new and less
experienced teachers (11.32). An outcome of this was that in 1974 the
course was extended to all teachers except the completely inexperienced;
also to teachers of the humanities, with appropriate options (11.4)

12. More generally, the project of which the course was a part, had the aim
of evaluating courses of training for tertiary teachers and the issues
which arise from them (12.1). This was achieved
by comparing and contrasting the participants' expectations before the
course with their reactions to it after the course (12.2, 12.3) and
by analysing their general comments and criticisms (12.4). From this
some recommendations for change emerged, although it was clear that a
more complete evaluation of the course could not be achieved until
follow-up interviews had been given some reasonable time later.

13. The questionnaire on aims was designed to provide information to
improve initial courses (13.1, 13.2). It showed that in coming to this
course participants' thinking was generally oriented towards the lecture
contrasts between the views of the experienced and the less experienced in this, and in their perception of the needs of new teachers (13.4). They found their aims changing, as a result of the course setting different priorities to those originally expected, but on the whole, they accepted this (13.5, 13.6, 13.7) but the course could be improved in a variety of ways (13.8).

14. The follow-up study of participants in the year subsequent to their course showed that they considered themselves to have benefited from it in many ways (14.1). It was clear that there was a will to apply much of what was learned on the course. Although this was affected by constraints and difficulties encountered in participants' departments this led them to change their approaches to tutorials and lectures (14.2, 14.3, 14.4); define aims and objectives and attempt to evaluate their courses (14.5), and in doing so make innovations for themselves (14.6).

It was concluded that the course basically achieved its aims and the reasons for this are analysed. The lessons learnt should influence further courses (14.7).
11.1 Introduction

The Institute for Educational Technology has been offering courses in Teaching and Learning in Higher Education since 1968. These have been of two kinds (Table 1).

(a) General courses for teaching in mathematics, science and engineering. These have grown from two-day non-residential courses for new Surrey staff to seven-day residential ones open to staff in any institution of higher education, including those with considerable experience. In 1974 for the first time the course was extended to cater for teachers in the Humanities and Social Sciences.

(b) Short workshop courses in special topics, including several on objective testing and evaluation methods. Workshops on the Keller plan and small group teaching were offered in 1974.

11.2 Course A 1972

11.21 Description of the Course The 1972 Course A for new and less experienced lecturers was based on the experience of the two previous courses (1970, 1971) offered nationally and of two earlier courses (1968, 1969) which were primarily designed for University of Surrey teachers. Revisions, which have steadily lengthened the course, were based on feedback from participants, partly from lecture and course evaluation questionnaires.

It attracted 32 participants, from University and Polytechnic, including postgraduates as well as lecturers, whose experience ranged up to 5 years (Table 2).

The aim of the course was stated to be:

"To introduce new entrants to the profession to the teaching side of their work and to discuss problems in teaching and learning in higher education, with special reference to mathematics, science and engineering."

To achieve this, a very full seven-day course was provided, with activities from 9.15 a.m. to 10.30 p.m., when the bar closed (Table 3). The methods employed included lectures, half of which were followed by group discussions (total 28½ hours), practice lectures, educational aids workshops (total 14½ hours), a panel discussion, two optional group dynamic sessions and a
<table>
<thead>
<tr>
<th>Year</th>
<th>General</th>
<th>Specialised Workshops</th>
<th>Seminar or Conference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>(Surrey staff only) M,S,E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td>(Surrey staff only) M,S,E</td>
<td></td>
<td></td>
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<tr>
<td>1970</td>
<td>M,S,E</td>
<td></td>
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<tr>
<td>1971</td>
<td>M,S,E</td>
<td>'Objective Testing' M,S,E</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>M,S,E</td>
<td>'Objective Testing' (A) M,S,E (B)</td>
<td>'Institutionalization of change' Senior and Admin staff (C)</td>
</tr>
</tbody>
</table>

Notes:
1. The letters (A), (B), (C), (X) and (Y) are used in the paper to refer to the courses, designated Course A etc.
2. The letters M, S, E, H, SS, P refer to the subject (groups) of teachers for whom the course was designed as follows: M (Maths), S (Science), E (Engineering), H (Humanities), SS (Social Science), P (Physics).
3. Since 1970, the General Course has also been attended by Surrey post-graduate students.
The lectures and small group discussions were designed to deal with the problems facing the new lecturer as well as some underlying theory and covered the subjects: the purpose of a university; university government; the lecture; laboratory and group teaching; learning; how students study; student problems; use of the library; aims, objectives, evaluation, assessment and examinations, and audiovisual media.

The group discussions had always been considered a very important part of the course involving the development of attitudes through the sharing of ideas and experiences and contact with experienced teachers. The small groups were arranged as far as possible on a subject basis, and this year were led in most cases by participants of Course C (3).

The small-group practice lecture sessions were in two parts, the first being conducted with a TV camera and recorder which allowed each participant to see his or her ten minute prepared lecturette. The second, which was at
# TABLE 3

## TIMETABLE COURSE A 1972

### UNIVERSITY OF SURREY
Institute for Educational Technology

### COURSE ON TEACHING AND LEARNING IN HIGHER EDUCATION 1972

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TUESDAY</strong></td>
<td></td>
<td></td>
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<tr>
<td>19 Sept.</td>
<td>9.15 - 12.15</td>
<td>Registration</td>
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<tr>
<td></td>
<td></td>
<td>&quot;Purpose of University&quot; (Prof. G. Moodie) (16.30 - 18.00)</td>
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<td></td>
<td></td>
<td>Informal discussion in Bar</td>
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<tr>
<td><strong>WEDNESDAY</strong></td>
<td></td>
<td></td>
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<tr>
<td>20 Sept.</td>
<td>&quot;Audio-Visual Media&quot; (Mr. C.R. Towns) LD and display</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot;The Lecture&quot; (Prof. L.R.B. Elton) (14.30 - 16.00) LD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot;Self-teaching&quot; (Prof. L.R.B. Elton) (16.30 - 18.00) LD</td>
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<tr>
<td></td>
<td>&quot;Learning&quot; (Mr. D.E. James)</td>
<td></td>
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<tr>
<td><strong>THURSDAY</strong></td>
<td></td>
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<tr>
<td>21 Sept.</td>
<td>&quot;How Students Study&quot; (Mr. D.E. James) LD</td>
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<tr>
<td></td>
<td>&quot;Laboratory Teaching&quot; (Dr. P.J. Black) LD</td>
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<tr>
<td></td>
<td>A: Educational Aids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: Practice Lectures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A: Display of visual programmes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: Playback of lectures</td>
<td></td>
</tr>
<tr>
<td><strong>FRIDAY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Sept.</td>
<td>&quot;Group Teaching&quot; (Dr. P.J. Black) LD</td>
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<td></td>
<td>&quot;Aims, Objectives, Evaluation and Assessment&quot; (Prof. L.R.B. Elton) L</td>
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<tr>
<td></td>
<td>A: Practice Lectures</td>
<td></td>
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<tr>
<td></td>
<td>B: Educational Aids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A: Playback of lectures</td>
<td></td>
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<tr>
<td></td>
<td>B: Display of visual programmes</td>
<td></td>
</tr>
<tr>
<td><strong>SATURDAY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Sept.</td>
<td>&quot;Examinations and other forms of assessment&quot; (Prof. L.R.B. Elton) LD</td>
<td></td>
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<tr>
<td></td>
<td>&quot;Use of Library&quot; (Dr. M. Stevenson) LD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A: Educational Aids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: Practice Lectures</td>
<td></td>
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<tr>
<td></td>
<td>Buffet Supper</td>
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<tr>
<td><strong>SUNDAY</strong></td>
<td></td>
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<tr>
<td>24 Sept.</td>
<td>&quot;Aims of Course&quot; (11.00 - 12.30) D</td>
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<tr>
<td></td>
<td>Book Display</td>
<td></td>
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<td></td>
<td>Free</td>
<td></td>
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<td></td>
<td>Free</td>
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<tr>
<td><strong>MONDAY</strong></td>
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<tr>
<td>25 Sept.</td>
<td>&quot;Student Problems&quot; (Miss A. Newsome) LD</td>
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<tr>
<td></td>
<td>&quot;Student Views&quot; (panel discussion) LD</td>
<td></td>
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<tr>
<td></td>
<td>A: Practice Lectures</td>
<td></td>
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<tr>
<td></td>
<td>B: Educational Aids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Playback of video tapes made in Educational Aids workshop</td>
<td></td>
</tr>
<tr>
<td><strong>TUESDAY</strong></td>
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<tr>
<td>26 Sept.</td>
<td>&quot;University Government&quot; (Mr. H. Jones, Mr. D. Lockwood) LD</td>
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</tbody>
</table>

**L - Lecture**

**LD - Lecture followed by discussion in groups**

**W - Workshop**

**Coffee:** 10.30 - 11.00

**Lunch:** 12.15 - 13.30

**Tea:** 15.00 - 15.30

**Supper:** 18.30 - 19.30

**Bar:** 18.00 - 18.30

19.30 - 23.00
appraisal of a second ten minute lecturette from the other participants and a more experienced teacher.

One of the educational aids workshops was designed to stimulate interest in using audiovisual aids and relating these to the teaching and learning situation, through active involvement. Thus participants were given materials to make a transparency and a stencil for a prepared handout; they were given a series of slides concerned with criteria for good slide design and asked to design and record a commentary and synchronise the tape to the slides to form an effective means for self-teaching. They were also introduced to some simple techniques whereby they could produce their own good quality graphics, which also helped them to appreciate some of the problems they might encounter in working with professional artists in their own audiovisual aids units.

The second educational aids workshop (new in 1972) was designed to show participants that it was possible for a lecturer, with no experience of TV, with the support of a fully professional audiovisual aids unit, to produce TV material for teaching. It was not designed to produce a polished programme but to provide an accelerated experience of all the stages necessary for production, in order to give direct experience of TV on which to base future discussions and thought about which parts of their teaching might benefit from this particular medium in order to promote more effective learning.

Participants were given the choice of two unscripted but otherwise prepared subjects (i.e. graphics and demonstration equipment) to devise a teaching sequence, script and visual presentation for the production team (participants and producer) to turn into a short programme, or alternatively, to devise their own programme from scratch. One group chose this second alternative, accepting the limitations on the range of illustration possible in the short time available.

The display of visual programmes had similar aims, viz. to show participants the variety of possibilities and some measure of quality. Thus they saw extracts from a TV course which preserved the outstanding teaching of a visiting American professor, extracts from a service course extensively used in London, extracts from films made at Surrey showing equipment or demonstrations which could not be otherwise shown to students.

There was also a display of relevant articles and books, including the references listed in the lecture notes, organised jointly by the Institute for
However, this catalogue of methods failed to reveal what was undoubtedly the most essential requirement, if the aims were to be achieved. This was the creation of an atmosphere of mutual trust, so that participants felt able freely to give of themselves, and of total immersion in the activities, as so much had to be done in such a short time. It was thought that this atmosphere could be created through the great intensity of the course and the insistence on residence, and the reactions obtained from participants showed that this was indeed so. Just one indication of what could be done under these circumstances are the five minute videotapes, designed to be teaching aids, which were produced by the members in groups of eight in four hours each. This experience was so successful that it was repeated in 1973 (a sample of these was shown at the SDU Conference 1974 (4)).

11.22 Course evaluation The evaluation described here is that used in the course, although it was processed and summarised by myself. The evaluative work specific to the project is described in Chapters 12-14.

In keeping with previous practice, participants were asked at the end of each day's activities to rate each session in terms of its use and its interest, and also invited to make comments. At the end of the course they were given a more extended questionnaire including questions asking for the most useful parts of the course, suggestions for additions and omissions, and suggestions for topics which might lead to more intensive workshops or short courses. Previous ratings, in conjunction with comment both informal and formal, had been used to modify the course and to revise the material presented in the different sessions.

The value of this immediate feedback, while great, was sometimes modified by later comments. For example, the ratings for most of the discussions following lectures were lower than those for the lectures themselves, nevertheless, one participant at the end of the course said about the discussions "I occasionally found these rather frustrating, particularly after a coherent and well delivered lecture. This frustration probably showed in my daily assessment sheets. On consideration, I feel that the discussions helped me to clarify issues better than any other method could, and I should like to correct the impression I have given." Thus, ratings which were on 5-point scales, must be treated with care; for example, for twenty-five out
of twenty sessions, the average rating on interest was higher than on use, suggesting that the utility of many of the subjects explored in the sessions was not always immediately apparent. For the remainder, interest was rated equal or only very slightly lower, which included the practice lectures, rated the most highly of all the sessions in terms of use.

The rating differences between utility and interest were usually small, and the ratings themselves usually quite high, which suggested that the lecturers were able to excite the interest of participants whilst leaving detailed considerations of application to the discussion groups, rather than that their performance outshone the value of their communication. Indeed, it was felt that if a short course of this nature could achieve anything immediately, then this was probably not really worth achieving, and it was for the participants to work out for themselves what the implications for their own teaching of the ideas presented in the course should be.

The most useful parts of the course were seen (by 16 out of 22 respondents) to be those on group work (the discussion groups, the sessions on group work or the extra group dynamic sessions) and on lecturing (10/22) (whether the practice lectures - ranked highest by 5 out of 22 - or the session on lecturing).

There were many requests for more group work, whether in the form of a separate workshop or extra sessions in the course (most of these were from people who attended the ad hoc group sessions), others asked for help in 'non-academic' tutoring or otherwise in the recognition of student problems e.g. drug-taking.

That the course was about values and attitudes as well as about knowledge and skills was not disputed. Thus the participants all recognised that they preferred to make up their own minds about their approach to teaching subsequent to the course. Thus, in the main, they found that the sessions presented for them no cut and dried way of presenting a lecture, no specific methods which they should use, but rather, much to think about, and possibilities and alternatives to consider in the light of their own situations, limitations and capabilities. Thus, in answer to a question about the general impressions of the impact of the course, one participant wrote "surprise and excitement that the course aimed to affect our attitudes, not just our techniques", and "created enthusiasm for teaching and hope that this will not wane". Another wrote "I arrived asking the question 'How can I teach more effectively'? - I left asking 'How can we learn more effectively together?'."
group feeling being very great, and about being a worthwhile experience in terms of increasing awareness of other people, e.g., "I found this course a tremendous group experience. It introduced an awareness and group sense which I have never experienced before."

Apart from confidence, others felt "it increased my awareness of the problems of teaching and my knowledge of means of improving my teaching" or "..... a framework on which to build the lectures and groups I will take this year. (It) helped me to organise and identify what were previously 'fuzzy' aims and objectives" or "I had not realised that there was so much work being performed in Higher Education" or "it (the course) practised what it preached (with exceptions whose presentation faults emphasized point made)."

That such courses should "practise what they preach" is obvious; that this one was seen to have done so was encouraging for the organisers.

A quite unexpected and independent evaluation of the course was carried out by a member of the subsequent Course C, most of whom had in fact not attended Course A. One of these latter, at the end of an hour of the introductory discussion about Course A, remarked in some desperation: "I cannot understand a word of what you are saying but you all seem to have had a most remarkable experience." After that, Course A members present calmed down and became somewhat more coherent. They had, however, demonstrated that the desired atmosphere of total involvement had been well and truly created. (This division was not, however, without further effect on Course C.)

11.3 The 1973 Courses

11.31 Course X In 1973, two overlapping courses were offered, courses X and Y. They differed from the previous year's courses A and C only in that whilst Course C had been designed for senior academics and administrators, Course X was designed for teachers with five or more years experience. Course X had a number of sessions in common with Course Y, although the majority of the sessions were devoted to discussion of topics covered in the common lectures. This derived from the value found by those members of Course C who attended Course A the previous year. In addition, Course X was partly aimed at providing a suitable experience for those likely to help new teachers who had attended a course of the type offered at Surrey. For this reason, Course X participants were offered the opportunity of observing the remainder of Course Y, e.g. discussions, practice lectures, educational aids.
A, but with slight changes. The introductory session included extended buzz groups, in which participants divided into the same groups which later would be together for discussions after lectures, for practice lectures and for educational aids. They discussed their own aspirations for the course which were subsequently discussed in plenary session. This provided a focal point early in the course where group members met each other and started thinking about the purpose of the course; the former was seen (by participants) to be the more important effect. This was in contrast to Course A, in which a controversial introductory lecture produced the lively discussion intended — it is therefore difficult to compare these alternative approaches.

A significant departure from previous practice was the absence of discussion leaders from the group discussion. This arose partly from the regular use of a small number of experienced tutors in the annual course (one of whom was attending Course X) and partly because of the success of the voluntary group discussions in 1972. This led to predicted unresolved tensions and frustrations in many instances, and was considered to be a failure, in contrast to the success of discussions in 1972.

11.4 The 1974 Courses

Two developments took place in the Teaching and Learning courses designed for 1974. Firstly, it was offered to both more and less experienced teachers, but not to completely inexperienced teachers. This arose from the way in which the course was presented. It promoted a type of thinking about issues and problems involved in teaching and learning in Higher Education which was best done from a position of experience. This was interpreted by the organiser as setting a lower limit, but not an upper limit on the experience of participants. It also required that participants come to the course, not to receive 'hints and tips', but to develop their thinking about issues and problems.

The second change was that the course was offered not only to teachers of Mathematics, Science and Engineering, but also to teachers in the Humanities. This development arose from the attendance of two observers from the University of Kent who confirmed the considerable overlap in the needs of teachers of Humanities and Sciences. The course was therefore run in collaboration with the University of Kent and had certain alternative options for humanities teachers, notably a greater emphasis on group teaching.

The final session of the course was a discussion with a small number of
return for a day to discuss problems which had arisen in their teaching since their attendance at the Surrey Course. This repeated a seminar held in 1973 during the early part of the summer.
A questionnaire was designed to explore participants' aims and intentions and changes in these brought about by the course; given before and after the course.

Chapter 12 presents the results of the open-ended part of the pre-course and post-course questionnaires. Chapter 13 presents the results and varied analyses of the numerically rated list of aims. The third part of the questionnaire was, however, not analysed in terms of changes produced by the course. This was because the time required to process the data led to the choice of work judged of higher priority. It was, however, used in the later interviews to check actual use of 'methods' by participants.

12.1 Introduction

The principal aims of the project were to evaluate the course and to examine some of the issues arising from this.

In order to become aware of these issues, a sample of participants of the earlier courses was drawn and consulted by interview. The sample was selected: a) geographically, b) from each of the two previous courses, c) from University and Polytechnic, d) over the range of subject departments of participants. The interviews were designed to explore: the kinds of success and difficulty experienced in teaching subsequent to the course, the broader issues emerging from this; the kinds of potential aims held to be appropriate for initial courses; to contribute to the development of an interview schedule; to contribute to the design of appropriate questionnaires and to pilot the same questionnaires. This subsequently led to all participants of the 1972 Course A being invited to contribute to the project by completing a fairly extensive pre-course questionnaire (Appendix 9) as soon as they had registered and after a brief introduction and explanation of the project on a personal basis. They were invited to continue their contribution by returning an equivalent post-course questionnaire shortly after the completion of the course (in their own time) (5).

The questionnaires were designed firstly to explore their perceived needs and aims in attending and what was achieved or not achieved; secondly to explore the relative importance of many potential aims for the participants' ideal course and the actual course and how well these were achieved and
12.2 Precourse questionnaire, participants' needs and aims

At the beginning of the course, participants were asked to state their general needs which might be satisfied by an initial training course and also their most important specific aims in attending the course.

For the purpose of the 'Preliminary Report' on the course to the UGC, participants' responses were grouped into needs and aims:

(a) which mentioned the lecture specifically
(b) involving learning and motivation
(c) about methods
(d) about evaluation and assessment
(e) which were global or general

They were further sub-divided for convenience, with examples of key words and phrases used by participants (in all cases direct quotes). In this, participants' aims were generally quite clearly about increasing knowledge, improving personal skills or developing attitudes in so far as these can be separated.

(a) Aims involving the lecture were:
   (i) improvement of personal lecturing technique (style, standard, delivery, pace, presentation, performance, speech, verbal presentation, technique...);
   (ii) correction of personal faults in lecturing;
   (iii) development of confidence (overcoming nervousness, apprehensions, developing authority...);
   (iv) improvement of preparation;
   (v) improvement of communication (conveying the main concepts, outline of the subject; choosing the right level...);
   (vi) gaining knowledge about the purposes of lecturing.

(b) Aims about learning and motivation were:
   (i) gaining knowledge about learning theory (learning methods, teaching theory, psychology, factors affecting learning; introduction to the basic literature; classification of (mathematical) concepts in abstraction and difficulty...);
(to get student aims and objectives into perspective; assessment of their needs; development of sensitivity to their needs....);

(iii) improvement of students' response and interest (involvement; feedback; how to teach students to ask and answer questions; how to stimulate and maintain their interest....).

(c) Aims about methods were:

(i) gaining knowledge about methods of teaching (new(er) methods; technique; alternatives to introduce variety, to complement and reinforce orthodox methods; present and planned methods....);

(ii) development of personal skill in different methods;

(iii) improvement of the selection of methods (reasons for different methods; matching of method to purpose; why people believe in other methods....);

(iv) gaining knowledge about course planning;

(v) improvement of knowledge and skills in the selection and use of audiovisual aids (improvement of quality and techniques of preparation; effectiveness, cost....).

(d) Aims about evaluation and assessment were:

(i) gaining knowledge about evaluation (how to test whether the purposes are achieved by the selected methods and which are the best methods; effectiveness of tuition....);

(ii) development of a critical approach to the assessment of one's own teaching;

(iii) development of knowledge about examinations.

(e) General or global aims were:

(i) knowledge about the purposes of a degree (expectations of society/university of a graduate);

(ii) development of career (attendance a useful tool for advancement; initiation into academic (teaching) community; increase personal motivation and interest in teaching as a career; organisation of teaching in relation to total responsibility....).

12.3 Post course questionnaire, participants' gains

To explore the success of the course, participants were all asked to describe the most important things they had gained from attending the course in terms of knowledge, skill and attitudes. These have been classified in the same way as the precourse needs and aims.
(i) improvement of lecture technique;
(iii) development of confidence;
(v) awareness of lecturing as a science;
(vi) better understanding of the effectiveness of the lecture.

(b) Gains involving learning and motivation were:
   (i) gaining knowledge about learning ("insightful learning instead of rote"; "appreciation of the small attention span in lectures"; "...now see the function of teachers as to help create an effective learning situation or environment");
   (ii) understanding of student motivation and problems ("more sympathetic and enlightened attitude to student problems"; "importance of motivation");
   (iii) gaining knowledge of factors affecting student response and interest ("definitely sympathetic attitude to students in the learning situation"; "more awareness of student-teacher interactions and reciprocal teaching learning situation").

(c) Gains about methods were:
   (i) (a) gaining knowledge about methods in general ("broadening awareness of variety of teaching techniques and ways possible in the process of teaching and learning"; "knowledge of some of the present educational methods and how these may alter in the future");
   (i) (b) gaining knowledge about alternatives to the lecture (self-teaching methods, Keller plan, Unit courses);
   (ii) (c) gaining knowledge about group teaching methods ("group teaching technique especially non-directive"; "stimulus in group activity"; "realisation that most lecturers had problems in tutorials...");
   (iii) improvement of the selection methods ("awareness of inadequacies and problems of conventional teaching methods");
   (v) improvement of knowledge about audiovisual aids.

(d) Gains about evaluation and assessment were:
   (i) gaining knowledge about aims and objectives ("clear definitions and the concepts of aims and objectives");
   (ii) "(development of a) more critical approach to (own) teaching";
       "increased knowledge and development of attitudes in standards of teaching".

(e) Gains which were general were:
   (i) increased awareness of problems in teaching and learning ("knowledge
critical awareness of problems and some solutions regarding teaching; increased awareness of complexity, and interest in education as a subject in its own right; understanding of tertiary education as a whole);

(ii) increased motivation (stimulated a healthy attitude towards teaching; ...greater interest in teaching; course strongly motivated me);

(iii) others (constructive framework within which to build confidence and technique; some specific skills and confidence in some activities; encouraged to find that many of the problems already experienced were typical, better equipped to cope with these; seen various people's attitudes (in group discussion) to teaching systems).

12.4 General comments and criticisms

Other general comments about gains in attending the course made which seem especially noteworthy: feelings regarding desirable innovations and fundamentals reinforced, realisation that (my) own educational ideas (were not) cranky but shared and part of a discipline; helped tremendously in giving many teaching methods and systems that would not otherwise have come to notice; ...checking of pessimistic drift into the feeling that nobody really cares about education....heartening to see that many individuals cared passionately; a chance to work out in the small group discussions the short-term and long-term aims of (my) own teaching. To me, these group discussions were the most valuable part of the course as I was forced to define my ideas on teaching and these therefore (will be) both easier to pursue and easier to modify. In general the course did much more for me that I expected. Quite honestly I entered with no expectations other than a week's boredom and a week lost to research and the preparing of next term's lectures; I was pleasantly surprised.

That the course achieved aims other than, or in addition to the aims which the participants had is very clear from the number of times that certain aims were mentioned and the complete absence of some of the pre-course aims. Thus, the majority mentioned the lecture before the course, but only six afterwards; only one or two mentioned tutorials before, but twelve mentioned small group teaching afterwards. In this way, it is clear that several participants found that some of their aims were not met, others realised that some could not be met in a short course, but the majority found their aims...
Criticisms, i.e. regarding things which participants did not like, or which the course did not achieve, were relatively small in number. Of these the most important would seem to be that the various speakers should make the subject of their talks more immediately applicable; that there were no practice tutorial and other group sessions; that were was inadequate discussion about course planning (especially in terms of aims and objectives and integration of methods, assessment and examinations), about teaching highly intelligent students, about teaching unmotivated students; that the practice lecture sessions were too short.

One participant felt that there were not enough participants of his own subject; another felt that (mathematics) teaching was different and this required special techniques and methods which were not discussed, in particular the problems of concept formation in this subject were not discussed. Another wished alternatives to the Keller plan to be given as he became "suspicious as it was over-enthusiastically presented".

In many of these comments it was clear that participants recognised the limitations of a short course and the compromises that had to be made in designing such a course. Nevertheless, it would seem to be reasonable that a day might be spent in optional extra activities, e.g. objective testing, longer practice lectures, voice exercises, individual help with preparation, further work with audiovisual materials, group dynamic sessions and practice tutorials (which might take the topic of University aims and objectives to develop further) and so on.
13.1 Selection of Aims and Course Design

An important input into course design is the aims which participants and potential students of a course consider desirable and important. However, professional training courses are necessary only so long as learning by experience is less efficient. That is, there are insights into the professional experience, there is a body of knowledge derived from it and there are analyses of the skills required for successful performance which can be passed on to participants to enable them to benefit from the experience of earlier generations. In addition, the development of appropriate attitudes would require attendance at a course rather than the reading of a book. This implies that course designers will themselves properly have aims for their course. These will not necessarily be recognised fully by those who attend but in a successful course will not only become recognised but also achieved.

The Teaching and Learning course is attended by members who bring a wide range of experiences. For the 1972 course in particular, the majority had already had lecturing experience of up to five complete years, and all had had some teaching experience. This was the giving of papers at conferences or seminars, tutoring students or assisting in laboratory teaching. Coupled with their own experiences as undergraduates and postgraduates this gave participants a range of insights into the needs of their profession in its teaching aspect and particularly relevant aims of their own.

Thus the issues for the design of the course are the proper selection of aims based firstly on judgements about the needs of the profession both now and in the future, and secondly on those of participants; the readiness of participants to accept material related to the aims; methods appropriate to the achievement of the aims, and constraints such as what can be done in the time allotted, for how long participants can be released and course costs.

13.2 Aims Questionnaire 2

As part of their contribution to this complex area participants were asked to rate the importance and achievement of each of a list of aims derived from discussion with University teachers, in particular participants of former courses. This list cannot, of course, be considered in any way complete, but a sample only, containing examples of the kind of general and specific aims which a course for new lecturers might have. They were asked to rate these aims on "the importance which you attach to each aim for
immediately after the course on "the importance which you think was actually given to these aims in the course" and "how well you think the course achieved these aims for you".

This work has yielded information on the aims thought most and least important to participants, and on differences in importance relating to experience; on participants' perception of their needs in relation to those of new teachers; on the matching of these aims to course aims; on the achievement of participants' and course aims and on the relative success of the course in different areas for different groups. Some of this work has been presented in sections 12.2 and 12.3. Coupled with interviews, it has shown that participants' aims changed through the course and some of the strengths and weaknesses of the course.

13.21 Importance of Aims to Participants For the discussion in this and later sections, teachers attending the course with one or more years' experience are called 'more experienced teachers', new teachers and teachers with less than a complete year's teaching experience are called 'less experienced teachers', whilst newly appointed teachers in higher education, taken as a whole, are called 'new teachers'. 'Participants' refers to the whole group, including postgraduates.

Taken as a group (Table 4) the participants rated two particular aims as most important for themselves (26) 'to improve personal lecturing technique' and (13) 'to increase knowledge and methods of organising and conducting a lecture'. (22 out of 30 respondents rated the former as of 'very great importance'). These two aims were clearly of outstanding significance to participants, rather more so for less experienced teachers than for more experienced teachers. The next most important aim also reflected a standard teaching situation.

More experienced teachers, however, rated even more highly than the three aims above (31) 'to improve audibility and clarity of speech'. In addition, they saw (29) 'to increase awareness of personal annoying mannerisms' and (30) 'to develop an orderly blackboard manner' as being clearly more important to them than most other aims. This was in marked contrast to less experienced teachers who, whilst considering them important, found them less so than the more experienced teachers, and saw as more important some other aims, e.g. (8) 'to increase knowledge of other (cf. conventional teaching) methods' and (1) 'to develop confidence in teaching'. These, in their turn,
### AIMS THOUGHT IMPORTANT BY PARTICIPANTS (in order of importance)

<table>
<thead>
<tr>
<th>AIM</th>
<th>MEAN RATING ON 5 point SCALE</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 To improve personal lecturing technique</td>
<td>4.67</td>
<td>1</td>
</tr>
<tr>
<td>13 To increase knowledge of techniques and methods of organising and conducting a lecture</td>
<td>4.60</td>
<td>2</td>
</tr>
<tr>
<td>14 To increase knowledge of techniques and methods of organising and conducting a tutorial</td>
<td>4.27</td>
<td>3</td>
</tr>
<tr>
<td>11 To increase awareness of the variety of student approaches to learning</td>
<td>4.13</td>
<td>4</td>
</tr>
<tr>
<td>8 To increase knowledge of other methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 To increase awareness of the variety of possible designs of teaching situation</td>
<td>4.07</td>
<td>6</td>
</tr>
<tr>
<td>18 To increase knowledge of the variety of methods of assessment and their applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 To increase knowledge of the effects of stating aims and their applications</td>
<td>4.03</td>
<td>8</td>
</tr>
<tr>
<td>27 To improve the selection and organisation of the content of teaching so that all students 'get something out of it'</td>
<td>4.00</td>
<td>9</td>
</tr>
<tr>
<td>19 To increase knowledge of problems affecting student learning</td>
<td>3.97</td>
<td>10</td>
</tr>
<tr>
<td>12 To develop a practical interest in education as a field of study</td>
<td>2.60</td>
<td>33</td>
</tr>
</tbody>
</table>

were considered less important by more experienced teachers. Thus, of the aims considered important by both groups, there were significant differences of emphasis reflecting experience, awareness of personal deficiencies, anxieties and awareness of possibilities.

**13.22 New Teachers' Needs as Seen by Participants** On the whole, participants saw little difference in the importance of the aims presented to them for themselves as compared with new teachers as a whole. They did, however, see (2) 'to overcome initial apprehensions' and (22) 'to increase knowledge of methods of teaching in the laboratory' as considerably more important for new teachers, reflecting partly their experience and partly their lesser practical needs (Table 5).
The above table compares the mean rating of each aim on a scale of importance for participants (converted to a rank: first figure) with their mean rating of its importance for new teachers as they saw it (second figure in brackets). The seven aims listed are those for which the difference in mean rating was greatest.

More experienced teachers saw (4) 'to develop a critical approach to teaching' as considerably more important for new teachers, indeed they considered this the most important, presumably considering that they themselves had achieved this. In addition, less experienced teachers saw (28) 'to develop skills in small group teaching methods' as considerably more important for new teachers than for themselves.

Both groups agreed also that (3) 'to develop a critical awareness of standards in teaching' was more important for new teachers than for themselves, and for (12) 'to develop a practical interest in education as a field of study' the position was the same, though they considered this aim to be of lowest importance not only for themselves but also for new teachers.

Compared with their perception of new teachers' needs, both groups
for themselves but more experienced teachers thought that (31) 'to improve audibility and clarity of speech', (29) 'to increase awareness of personal annoying mannerisms' and (27) 'to improve the selection and organisation of the content of teaching' was considerably more important for themselves, and less experienced teachers thought (8) 'to increase knowledge of other (cf. conventional) methods' was more important for themselves.

Thus we see teachers attracted to the course who felt they were critically aware of standards in teaching, having needs in regard to lecture techniques, general for less experienced teachers, highly specific for more experienced teachers. The latter saw these needs as greater for themselves even than for new teachers as a whole and were thus expressing a need to attend the course to correct specific deficiencies of performance of which they were aware, while the less experienced teachers were more generally interested in teaching and learning problems. The preoccupation with lecture confirms earlier findings (6).

13.23 Achievement of Course Aims The aims which participants thought the course achieved for them are listed in Table 6 in order of perceived achievement.

These aims correspond quite well with the importance participants thought was given to these aims in the course.

Notable amongst these aims are (4) 'to develop a critical approach to teaching', achieved better for less experienced teachers. This implies that the course raised for participants possibilities which they had not considered and which they accepted.

Whilst more and less experienced teachers tended to agree about the relative achievement of the listed aims, more experienced teachers thought almost all were achieved less well than less experienced teachers did. Indeed whilst about two thirds of the aims were achieved on average at least moderately well for less experienced teachers only one third of the aims reached this level for more experienced teachers. Whilst accepting that more experienced teachers might be more critical of any course, this implies that the course was less successful for them and is likely to be less successful in promoting change and development. This does reflect their greater experience but also the difficulty of changing acquired habits and modes of thought. The course was, however, only moderately successful for the two lecture aims and poor in achievement of (31) 'to improve audibility
and clarity of speech", thought so important by more experienced teachers. Indeed, of the nine best achieved aims, only three were amongst the ten aims thought most important by participants on arrival.

13.24 Underachieved Aims For the purpose of this paper 'underachieved' or 'overachieved' aims are defined as being those for which there was great difference between the importance and achievement ratings given by participants (scales normalised). (Figure 1 and Table 7). It follows that there are many aims which are overachieved or underachieved and there are differences in the way different groups saw them. For experienced teachers, the most significantly underachieved aims were (31) 'to improve audibility and clarity of speech', (30) 'to develop an orderly blackboard manner'; next, but rather less significantly, (29) 'to increase awareness of personal annoying mannerisms' followed by (13) 'to increase knowledge of techniques and methods of organising and conducting a lecture', the more general, (26) 'to improve personal lecturing technique' and (32) 'to develop skills in the selection and use of audiovisual aids to learning'.

24
Each aim is located in Figure 1 by the mean of the participants' ratings of its importance for them and the mean of the participants' ratings of its achievement in the course for them. The bold line normalises the scales on mean and standard deviation of each variable. The dashed lines are drawn one standard deviation of each variable from the normalisation line.
### 'OVERACHIEVED' AIMS

<table>
<thead>
<tr>
<th>AIM</th>
<th>'OVERACHIEVED' AIMS</th>
<th>RANK</th>
<th>importance</th>
<th>achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>To increase awareness of issues, debating points in Higher Education</td>
<td>29</td>
<td>4½</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>To develop a practical interest in education as a field of study</td>
<td>33</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>To increase knowledge of application of the overhead projector</td>
<td>30</td>
<td>13½</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>To develop skills in making overhead projector transparencies</td>
<td>32</td>
<td>18½</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>To develop a critical approach to teaching</td>
<td>14</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>To increase knowledge of techniques of reproduction of notes, diagrams and other visual material</td>
<td>26½</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

### 'UNDERACHIEVED' AIMS

<table>
<thead>
<tr>
<th>AIM</th>
<th>'UNDERACHIEVED' AIMS</th>
<th>RANK</th>
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<td>27</td>
<td>To improve the selection and organisation of the content of teaching so that all students 'get something out of it'</td>
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Less experienced teachers found (31) and (26) above most significantly underachieved, followed by (27) 'to improve the selection and organisation of
The underachieved aims reflect on the whole the small amount of time devoted to practice lectures for each individual. The majority of participants did, however, accept that in a one week course there were so many things to experience that no more than a few hours could be devoted to this activity. In addition review and discussion of the practice sessions concentrated often on the strengths of the lecturer concerned, e.g. a lecturer who did not look at the audience or talked to the blackboard could communicate his own intense interest in the subject. They tended to be supportive and encouraging.

These 'underachieved' aims do raise issues about the desirability of arranging individually tailored sessions for blackboard practice, voice exercises, lecture preparation, talking in large theatres (arranged for one and found very useful); or of arranging group sessions concentrating on specific topics, e.g. selection and organisation of content, compensating strengths of lecturers, selection of audiovisual support material; and in particular of lengthening the course to ensure adequate practice and of ensuring continuing support for lecturers in their own department or institution in the months following the course.

Overachieved Aims

For all participants, the most overachieved aim was (12) 'to develop a practical interest in education as a field of study'. This is a most interesting effect of the course, clearly reflecting a development of participants' concept of education and its implications in the work of a University or Polytechnic teacher. Participants also agreed that (5) 'to increase awareness of issues, debating points in Higher Education' was overachieved, reflecting the high professional level of concern communicated in lectures and discussions, both formal and informal.

Surprisingly, more experienced teachers found (2) 'to overcome initial apprehensions' overachieved (though it was of moderately low importance and achievement) suggesting that though they saw this as being inappropriate to them, nevertheless the course was able to help to some extent in reducing apprehensions. Less experienced teachers found the achievement of aims connected with the overhead projector significantly overachieved and to a lesser extent (15) 'to increase knowledge of self-teaching methods', whilst more experienced teachers found (10) 'to increase awareness of the variety of possible designs of teaching situation' and (8) 'to increase knowledge of other
a critical approach to teaching overachieved, but in addition, more experienced teachers found (3) to develop a critical awareness of standards in teaching overachieved. This reflected the importance they saw these aims to have been given in the course. These aims have been treated above, in order of 'overachievement'.

This implies that the course has been successful on the whole in communicating new ways of thinking, in showing new possibilities and giving new insights into teaching to the participants. That these changes were recognised and accepted by participants was made clear in interview.

13.3 Conclusion

This chapter has presented information about the way in which a sample of potential aims for a course for new teachers was perceived by participants on attendance and on the way in which this sample was seen to be achieved. As regards the issues of course design presented initially, it has shown that there were areas in which the course was operating where there was a large measure of correspondence between participants' aspirations and course effects. It has shown areas in which the course did not operate well in terms of that which participants' experience of higher education had led them to expect and areas in which the course operated in a different and often surprising way. In the relatively unsuccessful areas, it was quite generally accepted that limitations of time prevented these being achieved well and that these areas were less important in the long term. This was particularly true for less experienced teachers. It did leave room for activities related to the specific needs of individuals, especially among the more experienced lecturers. In the relatively successful areas, it showed that even in a short course it was possible to communicate course designers' aims of a more broadly professional nature which involved attitudes to professional development as teachers. That all teachers made some positive change in their teaching as a result of the course supports this, but the relatively limited changes which ensued raises very important issues in the long term. These are that initial courses should be lengthened by a substantial amount, that short courses of a specific nature should be available to teachers on a large scale, and that there should be a considerable attention paid to the professional development of new teachers in their own institution. Of these, the latter two points are at the present time being covered on an institutional basis in a growing number of institutions.
experienced lecturers found much to benefit from attending the course for less experienced lecturers. This, coupled with the observation that many of the participants with no lecturing experience found themselves at times being unable to contribute to discussion while those with one or two years experience were able to see problems and issues arising from their teaching, suggests two things. One is that about one year's experience is desirable for maximum benefit from this particular course and two, that it is the experience that matters rather than the length of experience. This is, although maximum benefit may be derived by those with only a short experience, the benefit to be derived by those with say 10 years' experience is still considerable.

Specifically, for an introductory course of only one week duration, the course achieved many desirable ends. It would have been improved if formal discussions had concentrated on specific points raised by the course lecturers, some of which corresponded with points participants thought important; if sessions had been arranged for individuals to meet their specific needs and if the short practice lectures had been followed by discussion with an experienced teacher, trained to advise the participant. In addition, the need to make available a wide range of developed materials related to the specific subject areas of participants was seen in the follow up study, implying not only a suitable display but sufficient time for its study and discussion of its implications. This in fact implies a greater degree of staff commitment (in terms of time and planning) in the course, to meet the aims of participants and the constraints of the lecturer's job in reality.
14.1 General Effects of the Course

An evaluation of the effectiveness of this course in Teaching and Learning would be far from complete without an assessment of its long term effects. In order to understand these effects, whether on participants' thinking about issues in Teaching and Learning or in their action in planning and carrying out teaching, and in order to assess how well the course matches to the real situation, the great majority of course participants were interviewed late in the academic year following the course.

All those interviewed (90% of all participants) felt that attendance at the course had a positive effect on their thinking, and all have carried out some activity which was new or more effective for them. Thus each individual has made his own decisions in the light of his own personality and experience, and the needs of his students and the expectations of his colleagues as perceived by him. The most common changes have been in approaches to the tutorial, in the issue of lecture notes and handouts, in the use of the overhead projector and in thinking about aims and objectives.

14.2 Changes in Tutorials

As regards tutorials, very many participants have reported much more effective student involvement and activity. For example, one lecturer turns individual questions and problems back to the group, those who think that they do not have the same problem are liable to become the tutor at the chalkboard. In this way, he avoids the tutor-group relationship common in Science and Engineering, viz., the mini-lecture. Another uses multiple-choice questions as starting points for discussion and for diagnosis of difficulties, an approach greatly appreciated by students; he has encouraged colleagues to do the same. Another broke up three-hour sessions so that much more varied activities could take place, e.g. introducing press cuttings demonstrating statistical fallacies and requiring students to present and discuss their own solutions. He was very pleased they did so, and that the time he spent talking dropped considerably as a result of this and similar methods. Another, however, found that discussions based on readings of papers which students were expected to find using the Science Citation Index reached a much lower level than he had hoped, showing a need for training in this particular use of the library. Several teachers started group projects in which, for example,
Several teachers offered extra tutorial periods, attended by up to 20% of their class who brought a large number of problems and difficulties.

14.3 Lecture Notes and Handouts

Lecture notes and handouts have been used quite extensively by participants, especially for course synopses, complicated diagrams and tables and mathematical arguments. One lecturer gives full notes a week in advance and organises his lecture around the salient features and the most difficult concepts, as a result, finding a great deal of freedom and a more enjoyable lecture experience. His students greatly appreciate the usefulness of the notes for examination purposes. Another presented a quite detailed framework in the notes but found difficulties in balancing the amount presented with the work done by students in the lecture.

One teacher, after increasing the frequency of handouts, decided not to lecture, but to be present in class for consultation. Several students were present before these classes and several remained afterwards—all consulted him and all passed their external examination.

One problem was found in more than one low budget department, viz., that the cost of duplicated notes was prohibitive, even being questioned for very small groups of students. Another, giving comprehensive handouts felt that rather more ground was covered, and in greater detail than in previous courses, leaving more for students to revise. This had not, however, led to signs that it was undesirable.

14.4 The Overhead Projector

The overhead projector was used by many who had not used it before the course and more extensively by others, often in conjunction with the chalkboard. It was used as a chalkboard substitute to maintain face-to-face contact with the class; for the easy display of diagrams and tables (often in conjunction with duplicated sheets); with overlays and with working models.

Many teachers have noted the relative ease with which high quality transparencies may be prepared and used, with greater convenience than slides. One of these teachers, who had not used the projector before the course, regarding it as 'paraphernalia', found it especially useful for large classes, but found difficulty in ensuring a clean acetate roll was always available.
head projector could not as there was not one in the department; another had to rearrange lectures in a teaching building equipped for projection but found difficulty using the chalkboard at the same time owing to inadequate siting of screen and board and even found difficulty in arranging the availability of a projector.

14.5 Aims, Objectives and Evaluation

Many teachers applied themselves to the task of defining their aims for their courses and found that it clarified the problem of organising their courses and defining their approaches. Some found this an extremely difficult task, especially in defining objectives at a level higher than recall, one in particular being interested in defining objectives at synthesis and evaluation levels (7). One teacher, whilst defining his aims internally did not give them to students in case they were not fulfilled. Another gave an extensive list to students. Others asked students what their aims and objectives were in regard to their courses, sometimes by questionnaire. Another teacher got colleagues to agree on course aims, exposing the fact that their syllabus did not really have those aims.

Several teachers used lecture or course evaluation questionnaires and preknowledge surveys. Often these were based on questionnaires used in the in-house evaluation of the Surrey course described in the preliminary report or on the aims questionnaire of this project.

Several attempted progressively to structure their courses on a unit basis, leading for some to plans for a 'Keller' plan course in future years (6). Others made tapeslide packages, used film loops more; one integrated laboratory work and film loops and produced a unit based course; one teacher got one of his department's lecture theatres equipped for showing some of the excellent video-recordings available in his subject (shown at the course).

Many teachers reported an easier lecturing experience, e.g. one saw less need for a 'polished performance', more need for active student involvement in the learning process even to the extent of following up student suggestions knowing they would not work, finding in the process less burden to provide the answers (without the questions). Another, finding relationships with students easier and student response better, also found for the first time real enjoyment in teaching.

Others gave seminars on various aspects of teaching and learning, or
deal of interest in specific innovations, e.g. Keller plan.

In all cases, it was clear that teachers were not using a method, technique or piece of hardware for its own sake but for an improvement in learning of a kind for which the method was appropriate.

14.6 Innovation in General

The course has led to experimentation and innovation at least on a small scale for all, many of whom were less worried about trying out things new for them, though for many the course came too late to greatly affect the design of this year's courses, e.g. an already partly planned course was seen as able to derive little benefit from a definition of aims. For many, too, there was conflict with other activities; research which was so important and interesting it ate into leisure time; the writing of books; extensive lecture preparation for unfamiliar subjects, and so many disparate responsibilities, many felt it extremely difficult to carry out all of these at the level they wished.

Innovation, however, was not without its opposition. This was perceived as coming from traditionalists who saw innovatory activities as a potential threat, i.e. requiring them at some future date to carry out similar activities under student pressure. One teacher, criticised for 'spoon-feeding', felt able to reply 'it leaves me time for real teaching'. Another teacher working in a small department which was isolated from other departments, was disillusioned with staff who neither wanted to change nor know their students, but was glad of the opportunity of reinforcement of ideas on the course. Others reported interest in their activities both from those ready to adopt successful ideas as well as those waiting to criticise unsuccessful attempts to try new things out. However, disinterest was more common than opposition and most participants of the course found colleagues, including senior departmental members, were ready to offer support and encouragement. One teacher, probably the most experimental and innovatory of all, who had read nothing in education before the course, and had read considerably since, felt that young teachers had much more freedom to experiment than they realised. However, it was apparent that positive encouragement was a necessary condition for this experimentation to occur at least in the early years of a teacher's career.
The Teaching and Learning Course offered by Surrey University, in spite of its short length achieved many of its aims.

It aimed to bring together relatively new teachers, to further their basic skills, consider fundamental ideas about teaching and learning, to widen their knowledge of strategies and methods of teaching, and to assist them to begin to work out for themselves improvements to their own teaching.

It provided an environment in which teachers could leave their own institutions and reflect on issues and problems in Teaching and Learning in Higher Education in the light of their own teaching experience and that presented to them in the course.

While participants came to the course having aims largely related to the acquisition of teaching skills, mainly centered around the lecture, they went away knowing the course had achieved for them aims in other areas. The extent to which this implied that the course did not achieve what the participants wanted or that the course had in fact influenced the participants to change their ways of thinking about issues in teaching and learning was an important subject for investigation in the project. The results showed some innovation and experiment by all participants, small for some, extensive for others, demonstrating attitude changes brought about by the course towards an awareness of and concern for more fundamental issues.

That this was the best course so far offered on these lines was agreed by all those in a position to offer such an opinion. This would seem to have been due to two important factors, one, that the design of the course had been developed through feedback from former participants and that this particular group developed a strong group feeling and sense of purpose very quickly.

Quite generally, the results of this research, together with those of other projects in the field of training of University teachers and administrators, should influence the design of further courses.

As the result of the experiences gained, the 1974 course was made available to both more and less experienced teachers and to teachers in all subject areas, as a collaboration between the Universities of Kent and Surrey.

It is clear, however, that there are definite limits to what can be attained in short courses. There is a clear need for regular seminars and discussions in Universities and Polytechnics for those interested in problems
for new teachers; such provision varies very greatly within institutions and departments. There is a need for short courses in a wide range of subjects especially of the workshop type. Finally, there is a need for long courses, especially for senior teachers who wish to devote a major part of their time to developments in teaching and learning which may include giving help to new teachers and leading seminars and discussions. Plans for a postgraduate diploma, modelled on the Monash pattern of a two year part-time course have been discussed by City, Kent and Surrey Universities but have been delayed by the current financial problems of the Universities.


(4) ELTON, L. R. B. & KILTY, J. M., Courses in Higher Education at the University of Surrey. Staff Development in Universities Conference, Univ. of London, 3 April, 1974.


PART IV

CONCLUSION

Part IV examines critically the two evaluations in terms of decision-making by the various audiences of the two project reports (1, 2) (chapter 15) and in terms of lessons learned which could be applied to future evaluations (chapter 16). These are summarised (chapter 17).
Introduction  This chapter takes a retrospective view of the projects, adopting the theoretical position of Stufflebeam et al (3).

In 15.1 the four types of evaluation are related to the projects through the kinds of action-related questions appropriate to each of the decision-makers making the audience of the reports. These were listed in 1.42 (Figure 3) and are as follows:

primary audience; client 1 project sponsor
secondary audience; client 2 course organiser
tertiary audience; client 3 (i) course teachers (a) internal (b) external
         (virtual clients)
         (ii) others offering courses
         (iii) educational researchers
         (iv) those 'receiving' students
         (v) potential students
         (vi) advisors to students

In reading this and later sections this list of clients may be referred to on a folded insert, inside the back cover.

15.2 relates the general activities of each of the above audiences to the evaluations and their rationales. 15.3 and 15.4 present an analysis of the evaluative information presented in Parts II and III respectively. This information is linked with each class of decision maker and with the type of evaluation carried out, for which the questions of 15.11-15.14 apply.

15.1 Analysis in terms of Stufflebeam's model
15.11 Context Evaluation questions (3a) Questions relevant to the planning decisions of Client 1, the project sponsors, are as follows:

What should be the scope of the national provision?
What long term effects are likely to ensue from proposed developments?
What range of choices and opportunities should be available for students? (Schools Council)
What kinds of efforts in teaching do we hope for or expect? (UGC)
What kinds of conditions are appropriate to these efforts? (UGC)
What compromises are necessary to meet conflicts of ideals with realities, in resources and values:
   (1) between goals related to more general societal requirements (Schools Council)
related to: lack of awareness; cost; differences of view amongst senior members of Institutions of Higher Education in the valuing of goals or indeed of the need for teacher education at all; and the need for an on-going, developing, working consensus (UGC).

These questions are appropriate to Client 2 in view of his contribution to the national scene on both fronts, and the consequent existence of the two projects. They are also appropriate to Clients 3 iii; to Clients 3 ii, especially for the Teaching and Learning project; and to Clients 3 vi in the same respect, in view of the heterogenous nature of the Universities.

Additional questions will be posed by Clients 3 vi as follows:

Do we wish to advise students to attend such a course?
Will attendance provide the 'student' with the competences
(1) we think he wants (Switch to Science)
(2) we think we need (Teaching and Learning)?

15.12 Input Evaluation questions (5b) Questions related to decisions about structuring the designs of courses relevant to Clients 1; 2; 3 i, ii, iii, are as follows:

How clear are the goals of the course in operational terms?
Are sufficient alternative procedures, logically related to goals, considered?
Are sufficient resources available appropriate to their achievement?
What might be unintended effects of the course?
How do teachers view the goals and strategies adopted?
How should process and product evaluation be effected?
What commitment is required of teachers, administrators, counsellors (during or after the course)?
How can validated strategies be transferred to other Institutions?

15.13 Process Evaluation questions (5c) Questions related to decisions on implementation are as follows:

What procedures are operational?
What defects are there in the design; in the practice?
What potential sources of defect should be continuously monitored, e.g.
(1) teacher-student relationships,
(2) teacher-student agreement on course intentions and designs,
(3) adequacy of real resources of all kinds,
(4) the working of methods?
These are appropriate to:

Client 1, for generalisations to, and comparisons with, other situations and courses;

Clients 2 and 3 i, for development and change within the existing courses, and to

Clients 3 ii, iii, for indicating possibilities for development in other courses.

15.14 Product Evaluation questions (3d) Questions appropriate to all clients relevant to recycling decisions about the courses are as follows:

What are the attainments of the course?

What objectives have been or are being achieved?

How do these achievements compare with what was

(1) desired

(2) expected

(3) attained in other courses?

Other questions relevant to Client 2 (secondarily to Clients 1; 3 i, ii, iii) are as follows:

Have course changes been effective?

How can failures be explained in terms of structuring and implementing decisions (using input, process and product evaluation)?

15.2 Description of Clients

Before examining the linking of information and decision making, the most important decision makers themselves (primary and secondary clients) will be examined.

15.21 Schools Council (Client 1) The work of the Schools Council includes 'to find ways and organise means of reviewing and reforming the school curriculum'. In achieving this 'initiating curriculum development...has meant deciding priorities...identifying resources...' being 'sensitive to issues such as academic freedom, the advantages and disadvantages of certain styles of research (and) of evaluation'. Additionally, 'the Council has been able to provide a meeting ground between the schools and higher education....no less significant a landmark' (4a).

It has engaged in discussion and reformation of sixth form work to meet student expansion and to provide 'measures....to counteract excessive specialisation....to broaden the curriculum' for all and facilitate delayed
choices of sixth form and University subjects. In this it was attempting to assist the schools to meet both the individual needs of their pupils and the educational needs of the community as a whole.

Although the Council is not a research agency, it has functions which require the support of research and the use of research techniques. It thus sponsors work for the immediate and practical purposes of the Council's own programmes of activity after its research staff have assisted the Council to identify its research needs and advised the Council on the research agency likely to be able and willing to meet them. Thus it promotes work related to its object: 'The Object of the Schools Council (7th July 1970) shall be the promotion of education by carrying out research into and keeping under review the curricula, teaching methods and examinations in schools, including the organisation of schools so far as it affects their curricula.' To achieve this, it may undertake, or assist any person or body undertaking enquiries, research or development work.

Therefore the Council may make grants to institutions or persons in respect of expenditure to be incurred by them for any work of educational enquiry, research or development, or for any other purpose arising from its terms of reference. For the great majority of projects the grant-holder will be the university (etc.) which accepts a responsibility for the project, and employs its directors and staff. These grants are primarily intended for use in connection with schemes commissioned by the Council, but all applications for assistance in carrying out projects related to the Council's purpose will be considered, in the light of the programmes of work laid down by the Council.

However, the Council's committee structure is designed to provide as far as possible for a balanced expenditure of its funds over the whole area of the curriculum and examinations, and to apply rigorous criteria to applications for grants, which far exceed the funds available.

Thus in supporting the Switch to Science project, the Council's interest was in extending its information base in respect of sixth form curriculum and evaluation methodology, and in continuing work at the interface between schools and higher education.

15.22 UGC (Client 1) The UGC is a body of part time members (appointed by the Secretary of State for Education and Science) the majority of whom are drawn from the universities. It was set up in 1919 by virtue of a Treasury
Minute to advise the government on the financial needs of the universities. Its terms of reference were extended in 1946: 'To enquire into the financial needs of University education in Great Britain; to advise the Government as to the application of any grants made by Parliament towards meeting them; to collect, examine and make available information relating to university education throughout the UK; and to assist in consultation with the universities and other bodies concerned, the preparation of such plans for the development of the universities as may from time to time be required in order to ensure that they are fully adequate to national needs' (9).

The fundamental principle of the relationship between the State and the independent, self-governing universities in Britain is one of non-confrontation. This is valued on both sides, preserving the autonomy of the universities whilst they are in receipt of public funds, and relieving the Government of managerial intervention by ministerial directive and legislative control. The UGC then acts as an intermediary linking the two in a mutually acceptable, pragmatic and informal way.

The wide range of formal and informal contacts and links are on the one hand with the C.V.C.P.; with individual vice chancellors and other university officers, and with the A.U.T.; and on the other hand with Government Departments, with a Parliamentary Select Committee, with Research Councils, and with other bodies and committees. In its links with universities, visits bring members of the Committee and its advisory committees and panels into discussions with staff, students, officials and governing bodies about plans, teaching/research balance, teaching methods and intra-university cooperation and communication. In its links with Government, understanding of policies about national needs and resources, together with the above, help formulate a broad central strategy of development.

The UGC is the instrument for giving financial advice to the Government and for distributing the recurrent grants (salaries, maintenance etc.) and the capital grants (buildings etc.). This distribution is based on quinquennial detailed submissions from each university. These together, after adjustment made from an appropriate synthesis of the total national provision in each field, form the basis of the Committees confidential recommendations to the Government. This is a complex process relating not only to judgements of the detailed position for subjects and universities as a whole, but to Government intents in respect of student numbers, itself the subject of judgement about national priorities.
Quinquennial recurrent allocations are annual block grants, as are grants for equipment for teaching and research which are 'earmarked' like the capital grants. In the mid 1960's support for developments in Educational Technology crossed subject and field boundaries for the first time (10).

Because of the current economic climate, however, settlements are now subject to annual approval within the quinquennial setting, whilst they were formerly always accepted.

Whilst quinquennial planning provides universities with a stable base for development, detailed plans may be delayed or become impossible for a variety of local reasons. This may leave, as it did in 1972, an unreleased sum of money. Coupled with a general realisation of university teachers and students of the need to prepare teachers for their work, this led to opportune support of experimentation and development in respect of university staff development already described (1.3). Whilst the UGC's emphasis is that the collective initiative of the universities should lead to development, through the prospering of a vigorous and a creative university life, trends seem to indicate that a corporate autonomy is evolving through the work of the CVCP. This extends to work in the field of staff development. For

For the Teaching and Learning project, then, it was clear that the objectives of the sponsors were much nearer to those of the course organiser, in that the evaluation should add 'its weight to be thrust for change' (11).

The impetus given by the UGC in 1972 (sec. 1.3) was intended to be continued by further special grants from reserves in, for example, a re-examination of objectives of teaching, and of the processes of learning, which, together with the exploitation of modern media, might affect the respective roles of the lecture, the tutorial, the seminar and self-instruction whether from books or from taped material in a new or an established course; and of devoting time to the actual preparation of materials for the new forms of presentation, and not least to evaluation work which must accompany every step. Particularly the Committee are interested in inter-university collaboration which offers some prospects of wider and therefore economical use of materials which are expensive to produce in the first place' (12).

Once again in this offer, the UGC indicated criteria for their acceptance of proposals. These included 'the possible utility of the scheme to other universities and colleges; and the student numbers likely to benefit. In the case of expensive projects particularly the Committee will look for evidence of discussion and planning jointly with other departments and/or
Regrettably, severe changes in financial circumstances subsequent to their invitation precluded further UGC support (14).

The context of UGC involvement then, is to encourage developments of wide potential use, with wide dissemination of evaluation results. Thus it was taken that information was to be provided, to aid (autonomous) university (and polytechnic) teachers and committees to make their own decisions about improvements and developments in courses for their teachers and about secondment of teachers to courses, and to contribute to decision making in the long term about trends in course provision.

In this respect, the limitations of a short course led to a more rapid identification of essential areas of investigation.

The lead given by the UGC (others, e.g. the Nuffield Foundation (15) and the Vice Chancellors Committee are already doing substantial work) should be especially noted, as it is set in a context of emphasis on research, defence of academic freedom (including 'bad' teaching), resistance to assessment of teacher effectiveness and consequent opposition to the notion of 'training' (here emphasised as teacher education).

15.23 Course Organiser (Client 2) He can be considered as an agent for change working within a specific university setting and also within the wider setting of Higher Education. He is entrepreneurial in action, dissatisfied with current practice, working amongst many who are satisfied or who do not coordinate their change efforts. Indeed, as two university teachers who attended Course C have put it 'we are all pulling in the same direction: outwards!' and 'change in universities is like pulling on a net; it just gives', and so doesn't essentially change. He thus diagnoses unmet needs, and unused opportunities (3e). He mounts intra- and inter-institutional researches, evaluations and developments (16). These are of diverse kinds in order to explore potential changes and the promotion of change.

Thus for example, to continue the work in the field of Teaching and Learning in Higher Education and respond to the UGC offer (in 15.22), he (with others) made a further submission in respect of 'Training of Teachers and Administrators in Higher and Adult Education'. In this it was stated 'The lesson that has been learned above all others is that in the brief time available it is not possible to do more than to acquaint teachers with some of the problems that arise in teaching and learning in higher education, and
that for any real training a much longer time is needed, such as is for instance provided by the two-year part-time course being offered at Monash University, Australia. And 'A similar need, i.e. the need to train adult educators has been highlighted by the Russell Report.' Thus, 'The University therefore wishes to offer, jointly with City University, a two-year part-time course, leading to a postgraduate Diploma in Higher and Adult Education.' (extracts from Surrey University's application to the UGC of 21.9.73)

In respect of his own innovation, he is interested in formative and summative evaluation, generally in terms of purposeful institutionalised changes and the survival and development of the Institute.

15.3 **Information from the Switch-to-Science Project**

This section relates the project report to the four aims of the operational study of the B courses (aims (a)-(d) listed in 1.2). It reviews the information presented in each of chapters 3-10 directly pertinent to these aims, as illumination of the various problem areas and issues which arose in meeting the aims. It links this information to the potential decisions or decision areas involved and with the corresponding decision makers, together with any decisions known to have resulted.

15.3.1 **Descriptive information about the course** Much of the information in chapters 3, 4, 5 was intended to contribute to a general understanding of the course for all clients.

Chapter 3 gave an overview of the work; by giving a brief general background, the historical context (d) of the consequences of early specialisation (a) and specific problems for women students (a). It gave the overall course structure (d) and the philosophy of the course, especially the first year (d), together with global statistics for the course including internal/external transfers (d). (Context evaluation, all clients).

Chapter 4 outlined the selection process (a) and indicated its relationship with the timing of a recruitment advertisement (a) (d). It described students' qualifications and ages as a whole (a); particularly for university teachers (Clients 3 i, iii) and others who often judge academic competence in terms of A-level grades. This was to indicate the range of subjects offered and the maturity of a high proportion of students, and to aid decisions about supporting or teaching this or similar courses. (Input evaluation, all clients). Questionnaire and interview data completed and enriched the illumination of the underlying issues of student choice and their counselling and selection.
Chapter 5 presented the first year course aims, how its subject matter was selected and how choices were made about students' course continuation (d). (Input evaluation). It gave the overall pattern of the course and an extensive operational description of all aspects of the course (c) (d). This was to allow the course to be compared with A-levels and their equivalent. (Process evaluation, Clients 1; 3 ii, iv).

It indicated the increasing diversity of approaches adopted in the course partly because of the project (c) and partly due to increasing involvement of the I.E.T., much of which stemmed from the formative evaluation results of the project (c) (d).

For example, the use of the 'Keller Plan' in the course stemmed in very small part from early project work designed to meet student needs at the School-University interface (c), together with some idealised suggestions for unit courses with a multilevel and multimedia approach; but in large part due to the possibility of research and development work of interest to the course organiser at the time (17) (d). The decision to try an alternative approach to a particularly abstract part of the course to overcome student learning problems arose from information provided by the research (c). (Process evaluation, Clients 1; 3 ii, iii).

15.32 Evaluation of the attainments of the course Chapter 6 implicitly argued against discrepancy evaluation using (then ungenerated) behavioural objectives (30f), but used criteria chosen to suit the variety of audiences, related to an interpretation of one broad goal. (Input evaluation, Clients 3 ib, ii, iva).

It presented a description of the examinations (d), student subject options (d), and some comparisons of examination performance with 'regular' students (c) (d), in subsequent years, especially in the Partners stage, a feature peculiar to Surrey (d). (Process and product evaluation, all clients).

It was intended to give essential data (19) about the worth of the course, especially in respect of the efficiency of utilisation of University resources for a small but significant number of individuals. It highlighted the problem of establishing results of statistical significance to complement the subjective views of staff, but provided an analysis which highlighted some successes and failures (a) (d). Broad judgemental conclusions on overall success were offered (d). (Product evaluation, Clients 1, 2, 3 i-iv).
Decisions related to evaluation

This information, coupled with interview data offering extensive feedback especially on the first year (c), and student difficulties whilst in this and subsequent years, suggested a number of decision alternatives:

1. recruit better candidates;
2. fail students;
3. reject students as incapable;
4. increase (a) academic counselling
   (b) personal counselling
5. add methodological variety
6. devise specific learning experiences

Of these: (1) depended on recruitment problems discussed at length in later sections; (2) is inevitable for some; (3) regrettably occurred in respect of some University teachers; (4) a and b ii were adopted, with some department teachers readily available for academic counselling; (5) and (6) (ii) were adopted extensively (apart from project research which was in part carried out in collaboration), as (5) and (6) (i) depended critically on the autonomous views of departmental teachers who in some cases were very open to project evaluation data and suggestions (a).

Implementation of (4), (5), (6) in the Institute increased demand in staff time considerably. Not all specific suggestions were accepted, mainly on the grounds of limited resources or high cost, in absolute and relative terms, elements of decision-making not considered in this work.

However, many possibilities were tried out, often on a small scale by myself, acting as teacher vis-a-vis experimenter and officially as personal tutor to later cohorts.

This 'appointment', in my judgement, did not conflict with experimental requirements for two reasons: firstly, in the exploration of student motivation and learning problems, student interviewing in many instances automatically involved non-directive counselling, with effects often noted by those individuals counselled in this way; secondly, I did not accept the 'formal' tutorship offered for the 1969 group, the subject of the most extensive longitudinal study.

Problems of counselling decisions

The complexity of the decision in respect of supportive counselling which was facilitative rather than authoritarian (20) is indicated by the problem of 'transfer' to receiving departments, and the continuation of counselling, which depended on the views of individual
Extreme staff views were:
1) these students will obviously need extra help and should be given it on moral grounds (i.e. their risk in taking an experimental course);
2) these students need to survive in an environment in which learning difficulties increase; the teachers know how the subject is best organised; if the students cannot cope, they should not be taking the course.

Such difference of values, whilst a normal part of university life, reflected a serious variable influencing students of the course.

Thus, provision of temporary counselling might have simply delayed the inevitable, with the result of lowered respect for the course, affecting all students and a disservice to those eventually leaving before graduation. The solution adopted was that non-directive counselling was in fact continued beyond the first year of the course by the course director on a small scale, i.e. when requested. It was also continued on a significant scale by myself, often complementing departmental counselling, in a way agreeable to course teachers and students, which allowed confidentiality to be respected.

15.33 Learning experiments Chapter 7 presented descriptions and evaluation of experimental learning materials, designed to implement aim (c) in view of the lack of variety of methods used in the course. All of these were adopted by course teachers, though not necessarily in the form proposed.

These experiments were in most cases innovatory and in some cases were developments of my own previous work as a Physics teacher, judged an advantage to be capitalised upon (21). They related to reported difficulties or poor examination results and attempted to make efficient use of restricted time and assist students' motivation (c) (d). They used a variety of approaches often mixed together such as student choice; group demonstration, verbalisation and discussion; simulations; structured work-sheets; self-teaching situations; programmed practical work with objectives involving high-order problem-solving abilities (including synthesis), and inductive methods. The small numbers of students and the large number of variables led to the use of a quasi-experimental design (22), in which the experiments were essentially pilot studies of curricular materials. For such studies general questions are asked.

Are the experiences satisfying to students?
Do they clarify processes?
Do they enable concept formation?
Do they make a sufficient contribution to students' understanding?
Do they affect students' attitudes and values?
Do they extend students' skills in appropriate ways?
Do they stimulate the students to question, study or read further?
Are they acceptable to and manageable by teachers less used to innovative work?
Do they make excessive demands on resources of all kinds?
Do they demand sufficient of students or too much?

It presented my own judgement about the generality of the conclusions, about choice of learning experience, and about the management of a curriculum designed to meet diverse needs, interests and abilities in any set of individuals forming a student group (c). (Process evaluation for structuring decisions, Clients 1, 2, 3 i-iv).

15.34 Other experimental work Chapter 8 presented further experimental work focussed on students' learning problems, from the need to explore aim (b) and to establish comparative measures of student learning (c).

Decisions were made to adopt and develop the mathematics pre-knowledge survey and extend and revise the tested remedial work as a collaboration. The test was also adopted to supplement the selection procedures for very weak candidates and as a basis for extending their course prior to entry. Judgements about the effect of specific and extensive help to first year students were expressed.

Conclusions about validating conceptual analyses and sequencing learning opportunities, as well as estimating preknowledge using tests derived from studies of the subject matter were generalised to similar courses (23). (Process evaluation, Clients 1; 2; 3 i-iv).

The use of Physics tests led to extra-project recommendations for item-banking (Client 1). It further confirmed problems in conceptual areas which related not only to established intrinsic difficulty, but also lesser associated pre-knowledge (b). This led me to recommend that further research be mounted in this respect. (Product evaluation, Clients 1, 3 iii).

Information was presented about modes of study which indicated some adaptability of students, and gave some weak indications in respect of success and subject choice. Information from attempted research in student use of the Health Service and related counselling support was particular to
Relationships between measured variables and success reinforced principles of selection (d), indicated some minimal needs of school work (b), emphasised motivational factors (a) (d), but indicated problems of application to the selection process in spite of the strength of some of the predictions (Product evaluation for structuring decisions, Clients 1; 2; 3 i, ii, iv).

No decisions were taken as a result of this information, as it came too late to influence the selection process. Otherwise it potentially aided counsellors and selectors in this and other courses, but is not generalisable to school science courses.

15.35 Knowledge of Switch to Science courses The problem of student lack of knowledge of the opportunity to 'switch to science' emerged early in the course of the research. Chapter 9 illuminated this problem area by presenting information about the extent of the national provision together with student numbers, and about the extent of careers teachers' knowledge of these courses (a) (d). It presented information about the higher education context of decisions to offer unusual courses, which can be summarised in terms of institutional survival (and complacency) and comparative information about some of the courses (d).

It presented suggestions on potential student numbers and explanations of mechanisms blocking the realisation of these numbers to illuminate the real problems of schools careers advice and the related problems of information dissemination to potential graduates. (Here it should be noted that UCCA advertised (Guardian Tuesday September 10th 1974) courses which were oversubscribed or undersubscribed). (Context evaluation, Clients 1; 2; 3 i, ii, v, vi).

One university made an unexpected decision not to continue efforts to mount a course for very small numbers after learning of the existence of other such courses (Client 3 ii). This information has additionally been given to many students inquiring of Surrey, especially about biological subjects and particularly after the course closed (Clients 3 v).

15.351 Decision alternatives for recruitment In respect of apparent lack of knowledge of the courses, potential decisions were as follows:

(1) write to all schools with potential university entrants
(2) write to a sample of schools; conduct a follow-up study for
(3) write to a sample of careers teachers as (2)
(4) speak at conferences
(5) write articles for the Times Educational Supplement
(6) write articles for newspapers
(7) continue to advertise
(8) (a) persuade the CVCP to modify the CUER for unusual courses
(b) persuade Schools Council or others to provide alternative publicity.

Of these
(1) was ruled out on grounds of cost;
(2) was ruled out because of the imminence of the decision to withdraw the course at the time this was suggested;
(3) was carried out in this research, at least disseminating knowledge of some courses to those careers teachers approached (the results of the work were not, however, disseminated through the N.A.C.T. Journal);
(4)-(7) had been continuously carried out on a limited scale since 1966; the last at great expense;
(8) (a) had been explored;
(b) was recommended in the project report.

15.36 Evaluation summary Chapter 10 presented a summary of the research and information with implications for decision-making, and in particular, my judgement that the course as a whole was not really relevant to sixth form curriculum development (c). (Input, process and product evaluation for planning decisions, Client 1).

It did, however, indicate the remarkable consistency of selection of content as between similar transfer courses, but without performing a comparative analysis (d) (Client 1) (24). It argued, from my value position for a more broadly based approach to curriculum design, drawing from consolidated wisdom in curriculum rather than overemphasising content, and commencing with agreed syllabuses. This argument failed to suggest that more than one type of lower or higher level science course might be desirable to meet the needs of all. Such provision might in any case attract students to wish to do science after extending their general (vis a vis specialist) education in

* Courses such as that offered in 'Guidance for Higher Education' by Loughborough University (20-26 July 1975) should be noted here.
sixth form curriculum adopted (26) it is clearly possible to provide sufficient Mathematics in a shortened course for university science entry. But should candidates offer Physics (or Chemistry) in a higher level condensed course then they would be more easily counselled at a less vulnerable stage. These points were not made in the report (b) (c).

Other arguments were expressed which were intended to illuminate the context in respect of university course provision, vocational education and influences on student choice of course in higher education (Context evaluation, Client 1).

15.37 Value of the evaluation to different audiences
15.371 Course organiser (Client 2) The epitaph on the course indicates a major problem of evaluation in terms of its scope and timing (3f). This is that for all the process and product evaluation relevant to the many issues which emerged in the study, a number of factors of local context, outside the scope of the evaluation, together led to the final decision. These were: pressures of low student numbers; constraints of teaching resources, particularly staff (although in my opinion good teaching and learning requires a high degree of commitment from teachers); unpopularity of the courses in some quarters and the need for a young Institute to grow in strength in a variety of ways quite apart from this one course.

The course was not, however, at any stage offered to a consortium of departments receiving students after the first year. Similarly, there was no exploration of the notion of a flexible set of unit courses to suit a broad range of undergraduates (many of whom had found some of the project materials useful). Thus whilst information was provided, and suggestions were made relevant to the decision to (dis)continue the course it was only a small part of the whole.

The death of the 'non-identical twin' course, originally part of the research brief by virtue of the common element in the first year for 'arts entry' students, was apparently caused by the same illness (27). Reduced student numbers coinciding with political pressures caused that course to terminate exactly one year later. Two of the external causes of the 'failure' of both courses were seen as overlapping: (1) lack of encouragement of students to follow an unusual course by teachers and (2) difficulty in making the course known in the standard, comprehensive, national handbooks.

Apart from decisions made as a result of process and product evaluation information given informally and in early drafts of the report, the following
points were made by the course organiser in respect of issues illuminated by the research (28).

1. The main conclusion is that it is possible in one year to prepare students with virtually no science and little mathematics for normal University science courses. I have made this point frequently at meetings.

2. On the other hand, there is need for continued help to such students in many instances. We have tried to provide this whenever possible to students who had left us for courses in other departments.

3. The course showed up the value of programmed texts and of the Keller plan in bringing students with widely varying backgrounds to common levels.

4. Points 1, 2, 3 above are helping to form the first year of the Combined Studies in Science course which we are planning at present.

5. Experience with adult students, which is in striking contrast with the failure at Sussex, is helping me to formulate course proposals for mature entry to the University.

6. The fact that the course had to close for lack of numbers, once pressure on university places decreased, speaks for itself. It has strengthened my conviction that sixth form specialisation is educationally and socially bad.

Others offering courses (Clients 3 ii) Comments from recipients of the report are as follows:

'The steady, small, but increasing demand for this course shows that there is a need for such a course to allow students without 'A' level (subject) to study it at University. I personally feel it should be brought more to the attention of university applicants.' (29)

'I read it with some interest and congratulate you on your very thorough studies. I must say it must have been a little disheartening that your Transfer Course eventually folded up through lack of response from candidates (as did ours).' (29).

'I am feeding this (report) into discussions which are taking place in the University concerning the development of our Science curriculum where I think it will cause a good deal of interest.' (29)

Schools Council's reception of the report In making decisions after receiving the report, it is important to note that Schools Council gave the project the title 'Syllabus matching between School and a Technological
Indeed in a report (7b), unfortunately not seen until writing this thesis nor pointed out at any time during the project, the project is described as

'An exercise in syllabus matching between school and a technological university, including the study of sixth form syllabuses and their suitability for courses at a technological university with special reference to some of the unconventional courses offered at the University of Surrey.'

The research objectives accepted by the Council included none of the above. Additionally, a preliminary report, of substantially the same form and content as the final report, had been presented and viewed more than a year before the end of the project, without comment on the above. In fact this particular form of words was taken from the original submission to the Council, which was changed significantly to

'To study the reduced science courses offered at the University of Surrey, with special reference to the relevance of such courses to the problem of the swing away from science and to curriculum development in the sixth form.'

The final decision by the Programme Committee confirmed the recommendations of the 3 committees which had previously considered the report (alongside 6-8 others of similar weight). This was not to authorise publication in view of its length. It is notable that though 'it was thought to be an interesting exercise which was a useful paper for further research' (unspecified) and that 'the appendices were a useful part (which) would be lost in any summarising', it was 'thought to be limited in its use to schools' (31).

In addition, the limited generality of statistical findings based on small numbers, and criticisms of minutiae e.g. the lack of SI units and the use of very simple circuity in some of the material, showed that some members of these committees had completely missed the point of the study. This by its nature should have been 'illuminative' and should have given indications of the utility of what were essentially pilot trials of experimental materials, which were designed to meet, and did meet, both student and course needs. For example, in preknowledge testing it was a rare student who had familiarity with SI units. In such cases, an equivalent test form was available but not required. Similarly, the interest in specific appended
samples of materials (details in a broad evaluation) selected to show validated principles held to be generalisable to other easily designed materials, indicated a conflict of "post hoc" purposes related to the misinterpretation of the evaluation rationale, undoubtedly related to the incorrect title given to the project.

It was thus a major failing on the part of this work that the nature of the decisions to be taken were not clearly communicated and that widespread dissemination was not achieved. However, the report was disseminated widely to Clients 3 i-iva and to others who had expressed interest in the work. The report is lodged in the Schools Council Library, joining other materials, which "may be of considerable value for research or other writing".... "available to students" or "other approved persons" perhaps to lead to "the application of a project" (8c). Thus the potential impact on careers teachers and potential students (Clients 3 v, vi) was not achieved, and the potential influence on specific curricular developments was limited to the work of those members of the Science Committees who were influenced by the report. No such influence has been made known to me through, say, requests to complement the sample of materials in the appendices. It thus emphasises Pace's view that "a collaborative mode of inquiry... (should be) brought to bear on the design, conduct and analysis of the inquiry" (30a).

The collaboration which existed, stemmed from the inspectoral role of the Council (8d) in which "project officers keep in close touch with the project for which they have particular responsibility" (8e). In this, aim (å) was emphasised strongly and helpful advice was given to approach other universities early in the project. However, the notion of trying out samples of materials on arts students in schools on a pilot basis only, considered by myself relevant to curriculum development for broader sixth form studies, was rejected, unless "done on a very systematic scale", related to your main objectives" (31). Thus, the notion of the "neutral social scientist" operating with "an independent orientation... not limited to the clients' intended objectives" (30b) was not accepted, as clearly such a systematic scale of inquiry would have made excessive demands on resources, detrimental to the stated aims.

Similarly, the procedural element involved in D.E.S. provision of a validly representative sample of schools led to the rejection of a survey of
arts sixth form students to determine the extent of their knowledge and interest in the possibility of 'switching to science'.

However, there was agreement 'that there is a need to educate schools, careers teachers in particular, to be aware that these switches can be made, indeed should be made in the case of pupils who have obviously made the wrong choice'. In addition 'the relevance to Working Papers 45-7 is obvious and it is very desirable that all concerned should know of these courses and their effectiveness when criticising any reduction in factual content of school syllabuses' (31). Thus, some influence from the project will hopefully be exerted on curriculum change.

15.4 Information from the Teaching and Learning Project

This section relates the project reports, re-organised into four chapters of this thesis, to their real and potential clients, i.e. decision-makers in respect of courses for teachers in Higher Education, and to the potential decisions or decision areas together with decisions known to have resulted from the information provided.

15.41 The courses Chapter 11 presented information about the Course studied and about the range of approaches used and their purposes, together with some information on participants' backgrounds, to contribute to a general understanding of the course. (Input and process evaluation, Clients 1, 2, 3).

It described the 'in-house' evaluation which indicated the breadth of effect of the course on participants whose autonomy was respected. It indicated some of the strengths and limitations of this approach to evaluation. (Process and product evaluation, Clients 1; 2; 3 ii, iii).

It presented descriptive information about the 1973 and 74 courses, indicating the way in which incremental changes developed in response to needs and capabilities. (Input evaluation, Clients 1; 2; 3 ii, iii, vii).

15.42 Course aims Chapter 12 described the early open ended investigations of the project which led to a focussing on a form of evaluation designed to shed light on the kinds of aims appropriate to a course of this kind. (Product evaluation for planning and restructuring decisions, Clients 1; 2; 3 ii, iii, vi, vii) (discussed in chapter 13).

It presented descriptive information from an open-ended questionnaire, about participants' needs and aims, and their subsequent perceived gains. It
further confirmed the kinds of change brought about by the course, indicated by the changes in emphasis on participants' goals, the language used and the comments indicating effects on motivation. (Product evaluation for planning decisions, Clients 1, 2, 3).

Some changes were proposed as a result of the work to meet more closely individual needs. Some choice was built into the 1973 course as a result, such sessions being rated highly. The specific suggestions made were not accepted on grounds of demands on resources, and the need to be highly selective in provision of learning opportunity in a course as short as this. Some further choice was, however, built into the 1974 course as a result of the lengthening required to cope with the increased range in participants' subjects.

Chapter 13 suggested a justification for initial training courses and related this to participants' experience and argued for their influence on course design in conjunction with other obvious factors. (Input evaluation, Clients 1, 2, 3).

The questionnaire analysis showed important course achievements together with factors critical to course design, particularly in respect of participants' range of experience.

Summative evaluation suggested that teachers with more than about 3 years experience should not be accepted for this type of course, without at least special consideration of their needs. This was in marked contrast to the benefit found by experienced teachers who were attending the course as part of a programme designed especially for them. (Product evaluation for planning and structuring decisions, Clients 1, 2, 3).

However, the longer term priority seen by the course organiser of finding ways of exploring opportunities for moving away from short initial courses for new teachers alone towards provision of more significant scope and effect prevailed. This aim of providing longer initial courses together with shorter, more directed specialist courses, overrode the information about the lower success of the course for such teachers at this time (see 15.45).

The questionnaire (slightly modified) has been used in at least one other 'Induction Course'.

15.43 Lasting effects of the course Chapter 14 presented information which showed the effects of the course as lasting beyond the initial enthusiasm of the course, in terms of the (generally moderate) innovation carried out. (Product evaluation, Clients 1, 2, 3).
In this respect, however, in this first year after the course, it could not be said that there was even one innovation which was not mentioned or experienced as a specific example on the course. This included examples of questionnaire techniques used in the research. Whilst it is to be expected that only a limited amount of experimentation can be carried out in the few months after the course, this suggests that courses of this nature carry a double responsibility in the promotion of staff development. They must not only provide examples of innovatory ideas but also provide sufficient examples in order firstly to broaden the base for teachers to develop from, and secondly to help participants to generalise their thinking about principles. This point was not made in the report.

This innovatory work related closely with recommendations of Course C about incentives, rewards and resources: 'An important factor relating to promotion on the basis of teaching achievements should be that a teacher had been actively involved in innovations or development work in teaching and learning' (32a).

Indeed, I attempted in many instances to encourage participants to publish their work in line with the point: 'research and development in teaching and learning should be as acceptable as research in a subject' (32b).

Similarly, difficulties experienced by participants, both specific and general, were supportive of the recommendation: 'the improvement of teaching, the continuing re-evaluation of the whole process of teaching and learning and the development of appropriate learning materials is the professional responsibility of all staff. To facilitate this work, each institution must provide support services, both audio-visual and those recently developed in many libraries. Also needed are a flow of information about new concepts and practices, and consultancy support' (32c).

This account of innovatory work was designed to assist all associated with such courses to make choices in respect of what they wanted from their courses, i.e. to illuminate the issues of teacher education in higher education by 'the provision of more complex bases for informed judgement' (30c).

(Product evaluation, Clients 1, 2, 3)

15.44 Decisions relating to the evaluation A specific recommendation made in the project was to arrange a display of a very wide range of materials from all subjects of participants to indicate current developments in Higher Education. This was rejected on grounds of cost and preparation effort. Whilst the former could be circumvented through loans of more expensive
materials and gifts, exchanges or purchases of cheap materials, the latter involved the limited resources of a small Institute and associated contributors. These were already greatly extended in preparing for the course, a factor which I did not consider.

Other decisions taken as a result of the project were to increase the amount of group work in the course; discussion groups to have a 'leader' (1973 failures predicted and verified by myself); 'leaders' to be carefully selected in view of the apparently different requirements of different subject groups.

The 1973 Course Y in fact was only offered as a result of my persuasion relating to the gathering momentum of such course offerings. I argued that should this course not have been offered, then its success might have been questioned, leading to a reduction in subsequent recruitment. This argument is seen retrospectively as adopting methods of 'disjointed incrementalism' complementing other similar uncertain steps towards the ideal. This offering was made in spite of the strain on resources (resulting in the choice of 'leaderless' groups) but led to a positive relationship between the two courses (54).

Not reported was a follow up meeting with a dozen or so participants of the 1970-72 courses (half from 1972) in which they read short papers about specific developments in their teaching, or on their thinking about special problems. These included self-structured learning, teachers' qualifications, problems of government, experiences in seminars and the use of the 'Keller plan' at postgraduate level. Those attending thought this meeting was beneficial and supportive. It was repeated in 1974 with somewhat less success.

15.45 Assessment by Client 2 Apart from decisions made in the light of information provided informally, the following points were made by the course organiser about the findings of the report (28).

1. The finding that all those interviewed had carried out some innovative action confirmed the essential soundness of our course and was immensely encouraging.

2. The aims investigation is full of valuable results and insights.

3. The stress on improvement of lecturing, shows that we must increase this component in our course.

4. The reaction of experienced teachers revealed the quite unexpected result that many came to improve their skills rather than to learn what was new. The implications of this are far-reaching. We have now decided to provide
a personal service to staff for teaching improvement.

5. The fact that teachers came to learn skills and left, having developed a critical approach to teaching showed that our main aim was being achieved.

6. The lesser success for more experienced teachers was expected and yet calls for changes, e.g. the one regarding a personal service.

7. The underachieved aims call again for a personal service. The over-achieved aims call for follow-up seminars. We are about to start these.

8. The fact that new teachers require professional development in their own institution is one we are well aware of. It has led us to consider a scheme by which we combine with a few universities only. The first of these is Kent.

15.46 Dissemination In this particular work, a much wider dissemination of the results was achieved. The two reports have been made available to Registrars of all Universities and Polytechnics in the United Kingdom and to many others interested. They have been individually disseminated to lecturers and professors, nationally and internationally, in polytechnics and universities, in subject departments, departments of education or tertiary education units of one kind or another, to the SRHE (33).

In particular, they have been lodged with the Co-ordinating Committee for the Training of University Teachers who have related the results with other work. In this broad field of their work they have considered modes of evaluation. They have been presented with a variety of approaches ranging from the ad hoc to the large scale (e.g. the UGC sponsored projects). In respect of the effects of courses on new teachers the longitudinal study of the work presented in this thesis together with other parts of the evaluation were presented to the Committee "as an indicator of what a good study can produce for our use" (34).

They have formed the basis of papers presented at conferences for university and polytechnic teachers and administrators in the UK, Europe and the USA (35, 36, 37, 38, 39).

They also have been disseminated to members of Courses A and C (1972) to whom they were of great interest.

The course itself has been publicised in other ways apart from the normal channel of information dissemination prior to each course, e.g. in the T.H.E.S. (40), in internal papers presented by course participants to their own departments or institutions or in publicised papers by course participants (41).
No specific decisions related to this dissemination are as yet known apart from the evaluation being held up in an exemplary way (34) as the UGC has postponed discussion of the results of the sponsored projects until Autumn 1975 when the majority will have been completed.
16.1 Proposed Rationale

This thesis has presented two case studies of evaluations commissioned to serve national needs. They were conducted, within the rationale of the agreed proposals, using a strategy which included very many elements of those which were developed later as "illuminative" (42) and "responsive" (43) evaluations. This strategy represents an attempt to move away from a "preordinate" mould, based on restricted models of human behaviour in real complex situations; and from clinically 'controlled research designs' derived from 'psychometric origins and towards more open design and impressionistic measurement' (44). That is, it attempts to provide a richer, more complete and useful picture of relationships and variables in the complex normalcy of teaching and learning both in the local and national settings.

The studies have been analysed in terms of a decision-making model (3), in which the research has been designed to provide illuminative information for planning, structuring and implementing decisions, but especially the first, to be made by a wide range of kinds of audiences. In each of the case studies I took the role of a 'neutral social scientist' (30d), using participant observation and intervening in a non-directive way; selecting issues for evaluation with 'an independent orientation' to effect 'the provision of more complex bases for informed judgement' (30c), but occasionally offering judgement. In this there were a number of methodological problems, discussed in 2.3.

In 15.3, the formative aspects of the first evaluation were shown to result in recognisable decisions, and worthwhile information for many audiences, but the summative aspects; the descriptions; the researches; the surveys; the projections and the judgements apparently did not serve the wider purposes of the sponsor. (This was in spite of the availability of a preliminary report for this project).

In 15.4 evidence was presented to suggest that the reports provided more relevant information, more effectively. Thus, partly by the nature of the difference in contexts, and partly through an improved 'interface' the second project met criteria in respect of 'awareness of the need for decision' more effectively. Indeed creating awareness may very well be a highly technical task for which methodologies remain to be developed' (36).
Nevertheless it is maintained here that there was a macroscopic focus (5h) in each case, at the very least by implication and generalisability, to provide 'system data' (3i).

This thesis then, concurs with the view that 'unless it (the evaluation) gains serious hearing when program decisions are made, it fails in its major purpose!' (11b) and that 'evaluators might well pay greater attention to the organisation-maintenance imperatives that influence decision-making, perhaps even address the covert goals as well as the formal goals of the organisation in their research. With better knowledge of the kinds of resistance to be expected, they may be able to devise more effective strategies for defining evaluation issues and for gaining their results a hearing!' (11c).

It is clear therefore, that a most important task of the illuminative evaluator is to ensure a more effective evaluation/decision making interface. This is particularly true in respect of 'the values and criteria (which) will be applied. These (decision alternatives and values) can be obtained by the evaluator only in interaction with his client' in which the 'evaluator is...perhaps more... responsible (than) the client for (this) identification!' (3j). He cannot effect relevant judgements himself without such extensive consultation and collaboration; he cannot himself be free to select issues for examination unless he can at the same time demonstrate the likely utility of his results.

Thus a synthesis of Pace's two extremes, the 'neutral social scientist' role (30d) and the 'client centred' role (30e) must be made in which the evaluator will have an important counselling role. In any case, the evaluator must naturally be selective, as any evaluation is almost bound to encourage a great richness and diversity of information to the surface because it involves the complexity of all the human beings under study whether students or teachers. He must therefore illuminate the whole gradually, and when the scope and breadth of the problem is seen, gradually narrow on issues selected and ordered in priority together with his client, in order to illuminate decision making. This will often include changing the project rationale and designated objectives.
Additionally, evaluators themselves must act as a team with separate or joint responsibilities, and complementary roles, which may serve different purposes. This will ensure that in the event of conflicts of role, that these roles will be adopted by different members of the team. It will ensure a more effective exploration of values and facilitate resolution of value conflicts. It will ensure a greater range of evaluation expertise is available. This will include for example: skills in interviewing especially of 'difficult' subjects; experimental design; data analysis. It will also ensure mutual support and encouragement e.g. to meet deadlines, to provide counselling for intrapersonal and interpersonal difficulties. It will facilitate a more fertile generation and critique of ideas and more complete cross checking of data. It will therefore ensure that the evaluation does 'involve very broad capabilities if the information requirements of decision makers are to be adequately serviced'.

Indeed, the broad capabilities demanded by Stufflebeam et al require the evaluator or team to have substantially greater information grasp than the decision makers. Whilst this will not always be true, especially when the evaluation is invited by sponsors aware of the need for evaluation, a close team relationship of evaluators and clients is proposed here as a means of optimising the delineating and providing processes of the evaluator/client interface. Regular protracted and intensive free and structured discussion within this extended team is proposed as a mean of: promoting awareness; selecting priorities; testing and weighting values (of both client and evaluator); reporting issues and interpretations of data at regular intervals; ensuring that attention is given to information and standards, both internal and external; checking style, language, length and organisation of reports especially in regard to controversial issues. It will also allow the requisite checking of the human values in the researched institution involving 'roles, expectations and sanctions operating formally and informally'. That is, it will effect that the transactional evaluation necessary to ensure that 'significant change affecting the central rather than the peripheral behaviour' of members of the institution is predicted and explored and used to set limits to the decision alternatives expressed, and to ensure that sufficient and sensitive argument is
expressed on critical decision alternatives.

This last is proposed as a safeguard to the evaluators as well as to the clients. It will also meet the differing needs of multiple audiences, i.e. all those who are in a position to make decisions, of whatever kinds, as a result of the evaluation. These will expect a return of information, whether as of right (sponsor), courtesy (consulted sources) or politics (individuals in a position to obstruct or delay response to evaluation changes). This will be achieved if carefully selected representatives of critical audiences be part of the 'extended team'. Such a team will also be an important source of descriptive data, indeed potential research associates, who will gather data, through their contacts with peer and subordinate colleagues, and in return, inform them of the progress of the project. These representative team members, will become increasingly able to educate their colleagues in awareness of the need for decision, and by virtue of their involvement, facilitate acceptance of the final evaluation report.

16.2 The model applied

In order to illustrate the possibilities in this approach, two evaluations carried out by myself since the two projects herein, are presented as incomplete case studies. They also illustrate an improved cost effectiveness of evaluation using the extended team approach. The two evaluations were separately commissioned by two bodies involved in the education and training of members of the medical, paramedical and nursing professions.

The first evaluation stemmed from the high failure rate in the examinations for the Midwife Teachers' Diploma, taught in six separate institutions of diverse types: polytechnics, schools of midwifery attached to hospitals, and specialist colleges. One of these Colleges was the professional body representing midwives, whose Council invited the University 'to investigate the role and preparation of the midwife teacher and any other aspect of the courses which are presently held which you consider to be desirable' (46).
The second evaluation stemmed from the reorganisation of the N.H.S., which led to a decision to/continue education of employees of all kinds, especially of the members of a wide range of health professions, at Regional level. The South West Thames Regional Health Authority (responsible for South West London, Surrey and West Sussex) invited the University to assist them in planning/provision for professional staff working in the community (general practitioners, district nurses, midwives, health visitors etc) (47).

The invitations were to the Centre for (now department of) Adult Education, which is extensively involved in initial and continuing education for a wide range of professions, on a national basis, and in particular those concerned with physical and mental health (48). My involvement was in part, related to my appointment to the Health and Social Studies Division of the Centre, and to my contributions to Teacher Education for these professions (including both specialist colleges of the first project).

16.21 M.T.D. Research Project In order to meet the requirements proposed in 16.1 the Research Team gathered a Working Party in consultation with the project sponsor.

This Working Party not only included representatives of the midwives' Professional Body, but also representatives of a cross section of teacher education establishments and of the midwives' Statutory Body, which is responsible directly to Parliament. The research team consisted of two educators, experienced in curriculum research development and/or evaluation. We were closely advised by another colleague who had extensive relevant experience, indeed who pioneered work with the professions, including their teacher education, and who was also a member of the Working Party.

The team was thus not only provided with a rich source of valid ideas, experiences and hence descriptive data, but linked closely with the decision-making processes inevitably related to the dissemination of the ultimate report. We were also provided with a 'filter'...
in respect of the language and style of the reporting. This was considered of crucial importance in the communication of tough recommendations, anticipated from the outset.

The territory for investigation was explored in several freely ranging discussions analysed by the research team which led to the gradual focussing on specific issues adjudged the most critical yet for which significant illumination was possible within the scope of a small project. A matrix was drawn up, consisting of 34 aspects of the problem, by 13 potential sources of information and each researchable cell of the matrix was identified (46a). This was in order to facilitate judgements of research priorities, organise data collection and aid the design of appropriate instruments. Specific hypotheses or evaluable questions were linked with all researchable cells (46b) which were used to structure subsequent interviews and discussions and assist the compilation of flow diagrams for a questionnaire (46c).

As a result of the investigation an extensive range of potential decisions was offered to the sponsors for their consideration (46d). Each of these was related closely to information derived in the research, interpreted by the research team in conjunction with the Working Party, who commented critically on a draft version of the final report. There were 6 long term and 23 short term recommendations for change, and 8 recommendations for further research. Some of these offered more than one decision alternative (apart from maintenance of the status quo) and some recommendations were linked together.

The most critical recommendations were in respect of collaboration between the two Bodies (Fig 1) and injection of knowledge from the educational disciplines (especially about examinations) into practices dominated by the medical disciplines.

It is maintained here that the efficacy of the evaluative research was increased greatly by the adoption of the strategies:

1 on-going collaboration with those in a position to make or influence important decisions relevant to the evaluation, and who understood the nature of the basic problems;

2 progressive focussing in Working Party discussions through a regular delineation-provision cycle, backed by Research Team discussions.
KEY

1, 2, 3   Institutions offering courses

1   Students (S)

Teachers (T)

• X Individual membership of X

•••••• X Membership since project

——— X Influence/report dissemination

•••••• Data gathering
Convergence towards recommendations for decisions to effect purposeful change. They facilitated conclusions of substantial import to result from a relatively small scale research (about 3 man-months).

Decisions made to date involve:

(i) restricted dissemination of the full report (102 pp) to the relevant Government Department; to Institutions offering the courses; to the Executive of the two Bodies;

(ii) dissemination of the report to (a) the Board of the Statutory Body and (b) to The Council of the Professional Body;

(iii) the production of an abbreviated report for wider dissemination and sale;

(iv) the setting up of Working Parties to examine some issues;

(v) slight changes in practice at the adjudication of examination results, in which 'borderline' candidates were scrutinised more carefully, with more attention given to the application of ideas on 'marker error', and to students who misinterpreted the examination rubric (the subject of many of the recommendations);

(vi) enquiries from teaching members of the profession to produce self-instructional materials as part of the provision for continuing education in the profession.

The second crucial decision (ii) (a) was a particularly critical one in respect of determining the likelihood of action in response to the evaluation. Considerable discussion between senior members of the profession representing both Bodies and conflicting views about dissemination led to the compromise that examiners would receive the report, but in a shortened version. Nevertheless wide dissemination was achieved. Fortuitously (vis-a-vis the original choice) one of the members of the Working Party is now a member of the real decision-making body.

In the report, a special attempt was made to write in a non-judgemental way, however critical were the comparisons with educational standards. Where opinions were offered in the light of insufficient evidence this was made clear.
It is yet to be seen whether this first collaboration with educationalists (outsiders) will lead to a substantial re-examination of current policies and practices, now 'illuminated' by the evaluation comment offered. However, in view of the struggle for dissemination, it is clear that papers describing the work need to be written for journals read by members of all relevant associated professions. Otherwise the report has been received with marked enthusiasm by senior members of the profession.

16.22 Community Staff Training Project In order to ensure an even more effective interface relationship than that of 16.21, a Steering Committee composed of the actual decision-makers, and representatives of groups of decision-makers, was set up by the Sponsoring body at the request of the research team. Early consultation with officers of that body defined the scope and duration of the project and established the basis of the professional working relationships with both Sponsor representatives and the decision-makers. The project was agreed after lengthy discussions as being most effective in providing context evaluative information to assist the R.H.A. in planning decisions. The project aims were agreed as 'to explore the following areas within the limits of available resources:–

1) The establishment of training needs;
2) The extent to which these are being met;
3) The identification of means of meeting unmet needs'.

It was agreed that the research would contribute to the development of a framework in which to get educational needs (of all kinds) in a broad perspective. Because of the small scale of the project it was agreed that it should be considered as the first step in (what should be) an on-going programme of investigation with more detailed studies being undertaken at a later stage. It was anticipated that this first stage might

1) provide a broad set of questions relating to training needs
2) identify some priorities
3) provide possible answers, alternatives and suggestions for some of the questions'.
The project itself stemmed from the recent reorganisation of the N.H.S., and a consequent decision to provide for continuing education and training on a Regional Basis from 1st April 1976. The new provision is being planned in detail by a separate Steering Party. The Research Project is linked with this Steering Party in two ways. Firstly, the research team and some members of the Research Steering Committee are also members of the Steering Party. Secondly, the objective of the Steering Party was modified to that of making immediate provision for six months rather than for a year, in order to be able to use the evaluation results.

The Research Team then liaises with those who make policy about educational provision, those who make decisions about immediate provision, those who control financing of courses and secondment of staff, those who plan and administer courses, and managers who influence the development of their own staff.

The first meeting of the Project Steering Committee received a discussion paper stating Stufflebeam's definition of evaluation, and agreed a set of terms of reference as follows.

1. To represent the views of other individuals and groups in the fullest sense. To provide data from these groups and to keep them informed of research progress.

2. (i) To collaborate with and advise the Research Team in delineating information relevant to decision making about continuing education provision.
(ii) To ensure that the Research Team is adequately informed about kinds of decisions to be made and the criteria for judging information provided.

3. To liaise as necessary with the Steering Party considering training activities on cessation of support by the South West Thames Regional Health Authority of the London Boroughs Training Committee.

The Steering Committee also accepted the points made in the discussion paper, which included the following.
"The first kinds of decisions to be made ideally are related to the scope of the provision as a whole. In this respect we need to work with all personnel who make or influence decisions or who could provide information relevant to decision makers. We need to identify needs and unmet opportunities and diagnose problems which prevent these needs being met; from this work, the second kind of decisions will be facilitated, namely the establishment of training objectives of all kinds and appropriate strategies for their achievement." (47).

The network of data gathering has been wide, involving staff of different disciplines, of different grades, throughout the region. Letters have been written to administrative staff, some of whom were known to oppose the research, inviting their collaboration, and suggesting specific ways in which they might help. Selected individuals in the region, including senior managers, and members of national bodies have been consulted. Groups of staff have been consulted by arrangement with members of the Steering Committee and others. Already arranged professional meetings, study days and teaching sessions have been used on an opportunist basis for this purpose. They have carried out brainstorming exercises and structured discussions often led by Steering Committee members and others acting as 'research associates'. The first interviews, and discussions were openended, but further clarification and especially 'triangulation' was effected in later meetings with different individuals and groups.

The discussion of issues in an institutionalised setting as a possible educational solution was also tested in part by the presence of Research Team members. This use of 'research associates' who put questions to professional meetings as an addition to their normal agenda has greatly extended the scope of the research far beyond that achievable by two individuals working to a restricted budget.

In one instance of the use of a member of the Steering Party in gathering data from a meeting of the entire group he 'represented' important problems arose. Firstly, there was resistance to the specific 'ad hoc' method used, viz to 'brainstorm'. Secondly, the group questioned the project validity and wanted to influence the research design without having been party to the early discussions. Thirdly, there was a need
for full briefing of important 'political' figures; i.e. the verbal briefing given was not considered sufficient. This posed constraints to the step-by-step progressive illumination strategy adopted.

In another instance, it was realised by the staff member responsible for in-service training that the 'problem centred' approach was superior to the more traditional 'solution centred' approach (48). It is hoped that further data gathering and translation into objectives might continue after completion of the initial project using multi-professional conferences and conferences for teachers from the institutions which provide training at present.

The framework for change to be offered will span a continuum from suggested organisational change (or change questions) to educational provision, including professional meetings as an 'in-between' solution. It will include an agreed philosophy of staff development and continuing education (49). It will relate continuing education to initial education (basic training). It will suggest educational aims common to a wide range of different types of courses.

It is thus envisaged that the collaboration with administrators and others, the involvement of a wide range of individuals and groups will contribute to a valid data base and ensure that decisions resulting from the work are more rational, and more widely accepted.
Introduction

The lessons learned from the two main evaluation studies lead to proposals for further work which can be divided into two kinds. Firstly, there is research work which could be conducted to answer questions which are suggested as worthwhile areas of investigation (17.1). Secondly, and far more importantly there are proposals for the development of a methodology for evaluation of the kind conducted in this work. These have been tested in two evaluations conducted from the Centre for Adult Education at the University of Surrey, in which I am presently appointed as lecturer (16.21, 16.22). This has assisted further clarification of the proposals summarised here (17.2).

17.1 Extensions of the project researchers

This short section provides a list of questions which arose during the research or as a result of the research, but which were not addressed because of time limits and priority choices.

Switch to science project

1) (i) What is the extent of a typical careers teacher's preparation for his role?
   (ii) What is the nature of the careers teacher/student interaction?
   (iii) What are the limits to his effectiveness?

2) (i) How well do sixth formers know of unusual courses?
   (ii) How well do sixth formers know of 'standard' courses?
   (iii) To what extent are they prepared to consider unusual possibilities?
   (iv) What are the implications for educational policy of the ways in which sixth formers (and others) make end-of-school choices?

3) What is an agreed common core of knowledge required at the beginning of degree courses based on science and mathematics?

4) Why does the learning of concepts and principles of electromagnetism cause especial difficulty?

5) What differences are there in study habits between students offering arts, science, or mixed courses

* department of Adult Education from 1.10.75.
at school and university and what changes in study habit occur as a result of progress from school to University?

6) What decisions have been made in sixth form (or other) curricula which were affected by the report to Schools Council?

Teaching and Learning project

1) (i) How well are the members of the 1972 cohort continuing their educational development?

(ii) How do their departmental colleagues react to them in respect of their education?

2) How do the innovatory activities of new teachers who attended a short course compare with those of other new teachers who

(i) should have liked to attend a course but could not,

(ii) did not wish to attend?

3) What decisions of any kind have been made as a result of the reports to the U.G.C.?

For each of the above questions a research design is judged possible, whether involving: surveys on carefully selected samples of students; extensive interviews and longitudinal studies; subject matter analyses, or fundamental research in learning. Two examples are suggested below.

To explore decisions made as a result of the report to the Schools Council, all those who received the report directly, or who consulted the report or others who had read it, would need to be identified. This would specifically include the members of the various committees of Schools Council who considered the report. They would need to be interviewed, initially on a highly selective basis, being invited to refer to the notes they made at meetings or on their copy of the report. They would also need to reread the report before the interview. The likelihood of their being willing to accept this task and their integration of the information from the report with information from the many others received subsequently, would make this research particularly difficult. (It has been easier for the Teaching and Learning Project).

To make a summative evaluation of the Teaching and Learning Course by comparing the innovatory activities of course participants
A checklist of innovatory activities (e.g. that of the Aims Questionnaire 3 - Appendix 9) could be used to provide an interval or ordinal scale (after weighting each item) on which each subject could be rated. Combined with data on their desire to attend an initial course (and their subsequent attendance at specialist courses) an estimate of the worth of initial courses could be made. The small numbers of subjects would preempt a classical study in view of the number of variables. These would include: subject field; type of institution; institutional characteristics; educational background (e.g. the extent of prior pedagogically related studies); teaching experience; departmental emphasis on teaching and research commitments.

An illuminative study, involving a research team of several workers, would be required for this difficult, but crucial field of work.

17.2 Conclusion

This work concludes by supporting the agreements of the Churchill College Conference (50) and maintaining that the research designs employed in the studies

1. met the criticisms made in this conference of previous practices (50a);
2. met their prescriptions for inclusion of observational data and flexibility (50b);
3. were both illuminative and responsive (50c) and
4. were reported in acceptable language (50d).

There was an improvement in relevance as between the studies (50e) but neither study gave an explicit statement of the value positions of the evaluator.

The work has explored some of the issues highlighted by this conference and has proposed specific ways of ensuring that these issues be met.

These are especially related to the interface relationship between evaluators and decision makers, particularly in respect of planning decisions in neomobilistic settings (31) and of improving the efficiency and effectiveness of the related context evaluation. The summary below takes for granted the well tried and documented techniques of data gathering illustrated and referred to elsewhere in this thesis. It takes as a starting point that the apparent simplicity of specific decisions may belie the complexity of the real situations.
1) The 'neutral social scientist' and 'client centred' evaluation roles should be synthesised.

2) Capabilities for context evaluation demand skills and techniques not yet well developed; thus the illuminative strategy is operationally the 'best buy'.

3) Evaluation is more effectively carried out by at least a small team of evaluators who can offer complementary expertise, mutual support, and more profound, responsive, flexible and complete analyses.

4) The evaluation team, if small, should ensure their work is continuously and regularly evaluated in conjunction with a representative cross section of members of the Unit in which the evaluation is being undertaken.

5) Extensive discussion will be required with the sponsors to establish an agreed rationale for the evaluation project. Agreement is required about
   (i) the limits to the scope of the enquiries especially in terms of the evaluation effort expected from the resources made available
   (ii) the probability of success in meeting the agreed aims
   (iii) the freedom of the evaluators and the potential strategies they might use
   (iv) the extent to which the sponsors might allow the aims to be changed in the light of information derived.

In this, the evaluators prior experience of such projects is critical; their counselling and educative roles may be required from the very inception of the project.

6) Evaluation must serve decision making. An Evaluation Steering committee comprised of a carefully selected and fully representative sample of decision makers should continuously guide evaluation choices and regularly receive status reports.

7) The joint task of the delineation of information requirements is a process in which goal questions (51) are agreed and
varied concerns and questions of participants, sponsors and other interested parties' (42a) must be met informally during the evaluation or formally at the final reporting stage.

8) The process of delineating information requirements should be related to priorities determined by the rationale and size of the project. This should ensure that the important issues are covered sufficiently well to weigh priorities for further investigation in an ongoing delineation - provision cycle.

9) The requirement for regular status reports will stimulate the evaluators to meet deadlines, to crystallise their thinking, to extract from the information obtained that which is most essential to meet the decision makers' immediate requirements, to provide information irrespective of the stage in the obtaining process reached. These status reports can be used as successive approximations to parts of the final report(s).

10) Evaluators must consult all decision makers i.e. authorities, power figures, administrators in a position to influence, block, support, disseminate, implement, gather information for or be affected by the ideas, suggestions and conclusions of the evaluation report.

11) The evaluators must ensure adequate knowledge of the job descriptions and role functions of all such as is ascertained early in the project, so that relevant designs are effected which ensure that proper consultation in the most appropriate political order is carried out.

12) The evaluators must ensure that each of these obtains sufficient, relevant, convincing information about the project at an appropriate time and in a sufficiently sensitive manner. Similarly, they must invite their cooperation, seeking information exchange.

13) The decision maker representatives on the Steering Committee should relate to those represented to ensure
   (i) adequate data collection from them
   (ii) the acceptance of the developing evaluation framework
(iii) the ultimate discussion and acceptance of the final reports.

14) The evaluators should adopt with the Committee a strategy designed to facilitate decision-awareness and openness to the exploration of issues judged by them as important. They should be prepared to adopt a stimulative and persuasive role, to lead as well as be led in their partnership with decision makers. This may include persuading decision makers to allow the decision making process itself to be put under scrutiny. It may include facilitating their openness in respect of:

(i) the characteristics to be observed;
(ii) the possible outcomes of data gathering;
(iii) the possible effects of ignoring observables;
(iv) educational values and standards;
(v) the importance of attending to information obtained;
(vi) the need to make values and criteria explicit;
(vii) the information weighting process

15) The Steering Committee should make available data about 'politics' and 'organisation maintenance imperatives' to which the evaluation can be sensitised. They should consider the likely effects of change on all parts of the institutional system and examine ways of dealing with the most critical of these effects.

16) In obtaining information, the evaluators should be ready to infer the existence of information from what is not said or done, just as much from what is given in answer to his goal questions or in his observations. For example, institutional collusion (52) may lead interviewees to hide (especially in an institutional setting) a need which may be openly discussed in another setting, or by a member of another group. Similarly the language used by a person consulted about his needs, will show clearly the limits to his insights into his own needs.

17) Ultimate dissemination of evaluation results must be by as many reports and papers individually tailored to meet the information requirements of as many audiences as feasible.
The steering committee itself should establish the channels of communication for the reports and be prepared to act as such channels. They should receive, consider and suggest revisions to the final reports in respect of their language, style and length. The Delphi technique (53) may be used effectively in achieving this.

18) Decisions related to the evaluation must be followed in order to effect improvements in subsequent evaluations. Only in this way can improved evaluations be effected, and evaluation contracts be agreed, as will ultimately satisfy both decision makers and evaluators.
(1) KILTY, J. M., Reduced Science Courses Suitable as a Preparation for Normal University Honours Courses in Science: Report to Schools Council, I.E.T. University of Surrey, 1972 (unpublished).


   (3a) pp 218-222; (3b) pp 222-229; (3c) pp 229-232; (3d) pp 232-235; (3e) p. 218;
   (3f) p. 29; (3g) p. 16, also pp 52, 96, 104;
   (3h) p. 19; (3i) p. 20; (3j) p. 42; (3k) p. 10;
   (3l) pp 100-103.

   (4a) Section 1; (4b) Para. 36-39 Section 6.


   (7a) Appendix B; (7b) p. 41.

(8) SCHOOLS COUNCIL, Handbook for Project Directors and Grant-holders, Jan 1970.
   (8a) Rules 1 & 2, p. 2; (8b) p. 7;
   (8c) p. 22; (8d) Rule 9, p. 3; (8e) p. 8.
(10) U.G.C.,

(11) WEISS, C. H.,
(11a) p. 137; (11b) p. 136; (11c) p. 137.

(12) U.G.C.,
Chairman's letter to Vice-Chancellors, 24.7.73.

(13) U.G.C.,
Chairman's letter to Vice-Chancellors, 28.11.73.

(14) U.G.C.,
Chairman's letter to Vice-Chancellors, 27.2.74.

(15) GROUP FOR RESEARCH AND INNOVATION IN HIGHER EDUCATION
for example, Newsletter No. 1, Nuffield Foundation, February, 1973.

(16) For example:
DAVIS, Q. V. & HILLS, P. J.,

PENTON, S., O'CONNELL, S. & KAY, S. M.,
A Teaching Laboratory for Continuing Education. International Conference on Educational Technology, City University, April, 1975.

WATERWORTH, G. M., MCKENZIE, J. & SHIRLEY, R.,
(18) In fact the 1975 Course has been oversubscribed by a factor of 2. This was the first time applications had been turned down on any scale.


(23) See for example:

(24) SCHOOLS COUNCIL SC 74/286 appendix to GC minutes 3/74, item III (iii); Governing council asked that studies related to 2 level courses should include 'the design of F-level syllabuses to take into consideration the possibility of there being some common core in each subject to enable the planning of each degree course to be based on an area of knowledge common to all undergraduates following that course'.

47


(27) HORNSBY-SMITH, M. P., private communication, comments based on a draft paper.

(28) ELTON, L. R. B., private communication.

(29) private communications, individuals in other universities.


(31) private communications, Schools Council project officers.


(33) COLIN FLOOD PAGE is currently writing a section concerned with lecturers' feelings and attitudes towards introductory courses as a contribution to a publication on the training of teachers in higher education.

(34) MAIN, A., Evaluation of Training Courses. Background paper for meeting of Coordinating Committee for the Training of University Teachers, 5.12.74.


(37) ELTON, L. R. B., Methods of Training University Teachers. Conference on the Training of University Teachers, Manchester University, June 1974.


(38) ELTON, L. R. B., Projekte der Hochschuldidaktik in Grossbritannien. Conference of the German Physical Society, Bad Nauheim, April 1975.


(46) KILTY, J. M. & POTTER, F. W., The Midwife Teachers Diploma. Published by the Royal College of Midwives, May 1975. (46a) p. 8; (46b) pp 10-16; (46c) Appendix 1; (46d) pp 84-102.


(50) MACDONALD, B. & PARLETT, M., Rethinking Education. Notes from the Cambridge Conference. Camb. J. Educ., 3, 1973, pp 74-82. (50a) Point I, p. 79; (50b) point III; (50c) point II (a) & (b); (50d) point II (d); (50e) point II (c).

(51) SCRIVEN, M., 'The Methodology of Evaluation' in Perspectives of Curriculum Evaluation; Tyler, R. W., Gagné, R. M., Scriven, M., A.E.R.A.,
(52) HERON, J.,
private communication: observes that there are institutionalised behaviour patterns which prevent people being authentic.

See also
ARGYRIS, C.,

COFFEY, H. S.,
GOLDEN, W. P. Jr.,

(53) CYTHERT, F. R. &
GANT, W. L.,

(54) UNIVERSITY OF SURREY,


'The Psychology of Change Within an Institution' in Rippey (ed) op. cit. (45), p. 240.


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APPENDIX I

UNIVERSITY OF SURREY
Institute for Educational Technology

Courses in Science and Engineering for students with Arts Qualifications

1. The purpose of these four year courses is to enable students with an Arts background to obtain qualifications in certain science and engineering subjects. At present this scheme covers the following courses:
   - Physics B
   - Electronic and Electrical Engineering B
   - Metallurgy and Materials Technology B
   - Metallurgy and Materials Technology with a foreign language B
   - Physical Sciences B
   - Biochemistry B

The letter B signifies that these courses are for students with Arts qualifications. You will be asked on the application form to state your preferred courses, but you will be given the opportunity to change this during the first year if you so wish. There is a possibility of transfer to Mathematics and other Engineering subjects at the end of the first year.

2. The first year of the above courses is common to all six and covers Introductory Science. At the end of it, students join those who have come up through the science sixth form to take the normal three year honours course. Students may take a sandwich year between the penultimate and final years of their courses, and this is compulsory in Engineering and Metallurgy. A syllabus of the first year is attached. While the topics are similar to those covered at A-level, the treatment is of a more adult character, and the course is adjusted to the needs of the type of student in it who in many ways is very different from the normal science sixth former.

3. The courses are based on the experience gained in the first instance with the "Physics B" course. The first students in this course, who entered in 1967, took their final examination in 1971. It is satisfying to be able to report that their performance has been of nearly the same standard as those from the normal science intake.

The minimum entrance requirements for the course are two subjects at A-level and three at O-level, or three at A-level and one at O-level. These should preferably include Mathematics and some science at O-level. Mature candidates will be considered individually and not necessarily on the basis of their written qualifications.

MATHEMATICS

Terms 1, 2, 3

Solution of quadratic equations; rational functions and their graphs; law of indices; logarithms.

definitions of trigonometric functions and their graphs; trigonometric identities and equations; circular measure.

Elementary coordinate geometry in two and three dimensions

Limits: differentiation of elementary functions; rules of differentiation; small corrections; inverse functions.

Arithmetical and geometrical progressions; binomial theorem for a positive integral index. Binomial series for fractional and negative indices. Maclaurin series.

Exponential, logarithmic and hyperbolic functions.

Maxima and minima of functions of a single independent variable.

Partial derivatives.

Technique of integration, application to areas, volumes and moments.

Vectors; scalar and vector products; derivative of a vector with respect to a scalar.

Elementary ideas on probability; mean and standard deviation; method of least squares.

CHEMISTRY

Term 1 (50 periods)

The structure of the atom

Qualifications

Bonding

Valency

INORGANIC CHEMISTRY

Equations and heats of reaction

The Periodic Table

Group properties of the elements and their compounds

Term 2 (50 periods)

Equilibrium

Thermodynamics

Energy of Reactions

Thermodynamics

Mechanisms of Reactions

Rates of Reactions

Colloids and Emulsions

Surface Chemistry

Colligative Properties of Solutions

Electrochemistry

Spectroscopy

Solutions

Nomenclature

Organic Chemistry & PHYSICAL METHODS

Hydrocarbons

Functional groups

Alcohols and Amines

Polymers

Natural Products

X-ray and Electron methods

Spectroscopy

Polarography
PHYSICS

Mechanics

Kinesiws of a Particle
Distance = magnitude vector. See also, Velocity = uniform = average and instantaneous. A vector quantity. Relative velocity.
Acceleration = reluctance motion with constant acceleration.
Kinematic equations \( v = u + at \) etc.

Dynamics

Concept of force
Newton's laws of motion (momentum)
Laws (force and acceleration leading to the concept of mass)
Law II
Law III
Polarization
Motion in a circle
Equilibrium of forces - resolution - couples - moments
Work and power. Kinetic and potential energy
Simple harmonic motion
Catenary - catenary
Pure rotational motion of a rigid body
Angular displacement - angular velocity - angular acceleration. Kinetic energy, Moment of inertia
(see section simple basic treatment only)
Frames of reference - simple discussion.

Properties of Materials

Brief discussion on the structure of crystalline and, say, rubber-like substances.

Elasticity

Special reference to tensile deformation. Young's modulus. Other moduli briefly.

Surface Tension

Definition - bubbles - rise in capillary.

Viscosity

Definition - factors governing rate of liquid flow through a tube - streamline and turbulent flow. Newtonian and non-Newtonian liquids.
Stokes' law.

Heat and Temperature

A thermay balance. Temperature scale based on ice and steam. points discussed - disadvantages mentioned.

Thermal capacity

Specific heat.

Conduction (briefly)

First law of thermodynamics

Molecular Structure of Matter

Evidence for this.

States

Their nature - the perfect gas. Gas laws and equation. Absolute temperature. A temperature scale based on a single fixed point (at this stage the ice point referred to) and pressure change at constant volume. The principal specific heats of a gas - Bethe difference. Induced and diatomic changes.
Kinetic theory \( p = \frac{1}{3} \rho E^2 \)
Vapours - critical temperature
Vapour pressure - saturated and unsaturated, Partial pressures
Heat gases - molecular state and Interaction
Joule - Thomson effect (facts only)

Limits and Collides

Luided and Solids

Geometrical Optics

Ray concept - reflection - mirror = Snell's law. This latter = relation between \( n, v, t \), radii of curvature and refractive index (tabled, not proved)
(Formerize of \( \frac{n_1}{n_2} = \frac{a^2}{b^2} \) developed object and image distances measured from focal)

Instruments

Telescope, microscope, prism spectrometer.

Wave Motion

Waves

Transverse, longitudinal. Standing waves. Doppler effect.
S.H.M.'s differing in phase leading to establishment of equation:
\( y = a \sin \left( \frac{2\pi}{T} (x - vt) \right) \)
Harmonic construction
Interference and diffraction.

Light

Refraction
Young's slits and biprism
Diffraction grating
Dispersion = group and wave velocity (described by diagrams)

The Electromagnetic Spectrum

Radiation

Energy transfer by radiation from a 'black body' - energy distribution in spectrum. Stefan's law.
Nature of E.M. radiation

as illustrated by a radioactive, Electric and magnetic fields.
Polarization (comparison with ordinary light).
Constancy of velocity of light in free space.

Electricity and Magnetism

Static electricity as introduction
Coulomb's law - electric potential - p.d. - the volt - lines of force and field \( E = \frac{F}{q} \)

The electrical circuit

E.m.f., p.d. current. Heating effect representing the work performed. The wall, E.m.f. and p.d. limited with the absorption and production of work.
Resisance - internal resistance of source.

Thermoelectric effect

Chemical effect

Electrolysis and Faraday's laws leading to suggestion of possible basic change.

Electromagnetism

The magnetic field

At the centre of a coil - due to a long straight conductor due to a solenoid.

Force

On a long straight current carrying conductor in a uniform magnetic field - between two long parallel current carrying conductors leading to the definition of the ampere.

Measurements

The moving coil movement - ammeters - voltmeters - the ballistic galvanometer.
The Wheatstone network - the potentiometer.

Electromagnetic Induction

The Neumann - Faraday law.
Self and mutual induction.

Capacitors

The parallel plate. Charging (by battery) and discharging. Field between plates. \( E = \frac{q}{2\pi d} \)
Lines of force - other forms of capacitance. In series and parallel. Effect of the charge on a capacitor.
Brief reference to early e.m. experiments (charging "isolated" sphere, etc.)

Alternating currents

Their production. R, L and C each on an alternating supply.
Phase relationships between V and I. Resistance and impedance (series circuit \( \frac{1}{L} + \frac{1}{R} = \frac{1}{C} \).

Electron beam

- the CRO. Force on beam in a magnetic field.

constancy of velocity of light in free space.
1 = Not understood at all  5 = Understood well.

Mathematics  Physics  Chemistry

--- 1969  --- 1970
Tests

(1) Preknowledge surveys* (Mathematics)

(2) Preknowledge survey* (Physics)

(3) Physics Self TestX (Mechanics & Optics)

(4) Physics Self TestX (Electricity)

† Devised by Dr. R. S. Taylor in 1969 at the author's suggestion, revised 1970 by the author and again 1971 to include items related to Keller Plan course and chosen revision text. (Tests & remedial work for 1970, 1971 as given to students).

* Designed by A. E. Ashworth36, (M.Ed; University of Manchester), used with his permission; presented here as material used in the research work but not developed in it.

x Acknowledgements to Educational Testing Service and the G.C.E. secretaries, for permission to use items in the design of these tests. E.T.S. items have been deleted from this report in accordance with their instructions.

Tests 2, 3, 4, may not be reproduced in whole, or in part, without the express permission of the appropriate authors.

Only Sample pages of the tests are included in these appendices. The full tests are appended to the Report to Schools Council.
1. Express algebraically:
(a) four times the sum of x and y
(b) the average of a and b

2. If \( x = 2, b = 6 \) and \( c = -10 \), evaluate:
(a) \( x - (c - a) \)
(b) \( (a + b)^2 - c^2 \)

3. Solve for \( x \):
(a) \( x = x + 6 - 3a \)
(b) \( x^2 + 1 = x^2 \)

4. Simplify:
(a) \( 2x - 2(3 - 4x) \)
(b) \( (x + 3)^2 - (3 - 2x - ax^2) \)

5. Multiply:
(a) \( (2x - 7)(y + 3) \)
(b) \( (ab - 5)(ab + 2) \)

6. Solve:
(a) \( 2x - 2(x + 4) \)
(b) \( x^2 = 4 \)
(c) \( 3x + 1 = 2 \)

7. Solve in each case the pair of simultaneous equations:
(a) \( 4x - 3y = 11 \)
(b) \( x + 2y = 2 \)

8. Find, using tables:
(a) \( \log_{10} 0.0004 \)
(b) \( \log_{10} 0.0004 \)

9. Find, using tables:
(a) \( \log_{10} 0.0004 \)
(b) \( \log_{10} 0.0004 \)

10. Express as the sum, difference etc. of logarithms, without calculating:
(a) \( \log_{10} 0.0004 \)
(b) \( \log_{10} 0.0004 \)

11. Find, using tables:
(a) \( \log_{10} 0.0004 \)
(b) \( \log_{10} 0.0004 \)

12. Find, using tables:
(a) \( \log_{10} 0.0004 \)
(b) \( \log_{10} 0.0004 \)
1) A moment of force:-
   A. is the product of force and speed.
   B. is the same as power.
   C. is the same as work.
   D. can be balanced by another moment of force.
   E. cannot be balanced by another moment of force.

2) By means of a beam balance as ordinarily used we:-
   A. detect variations in the value of the force of gravity.
   B. eliminate the effect of the buoyant force of air in weighing.
   C. compare masses.
   D. eliminate the necessity of having standards of mass.
   E. measure the same quantity as by means of a spring balance.

3) A simple machine cannot:-
   A. change the direction of the applied force.
   B. substitute a large force for a small force.
   C. have a mechanical advantage of 100.
   D. overcome a resistance greater than the applied force.
   E. increase the energy put into it.

4) If the frequency of a vibrating tuning fork is marked "256" its period is:-
   A. 256 sec. B. 2.56 per sec. C. 256/60 per sec. D. 1/256 sec.
   E. none of these.

5) If a car has a uniform acceleration of 3 ft. per sec per sec. and starts from rest, its velocity after 10 sec will be:-
   A. 3\frac{1}{2} ft. per sec. B. 30 ft. per sec. C. 150 ft. per sec.
   D. 300 ft. per sec. E. none of these.

6) Two Horses are drawing a tree stump from the ground. One is pulling to the north with a force of 300 lbs. and the other to the east with a force of 400 lbs. The magnitude of the resultant is:-

7) If by means of a pulley system, whose velocity ratio is 4, a man can lift a load of 280 lbs. with an effort of 80 lbs. then the efficiency of the machine is:-
   A. 35%. B. 66.6%. C. 94%. D. 87.5%. E. 57%.

8) A wave has a frequency of 20 and a wave length of 3 ft. The velocity is:-
   A. 60 ft./sec. B. 6.67 ft./Sec. C. 0.15 ft./Sec. D. 20 ft./Sec.
   E. none of these.
Physics Self Test

The test is divided into three sections.

Section 1 is composed of constructed response questions.

Section 2 is composed of multiple choice questions.

Sections 1 & 2 are the sections which comprise the self test.

Section 3 is also composed of multiple choice questions which are certain to be difficult.

Nevertheless, we would like as many as possible to do this section.

To answer each multiple choice question you will select the correct answer from the given key by circling A, B, C, D or E as appropriate on your answer sheet.

In order to make the correct selection to some of the problems you will have to calculate a numerical solution; do so on rough paper.

For any problem which requires you to assume a value for g, use g = 10.3 m/sec^2.

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Symbols used in the items were those used in the course, at the time, e.g., c = Coulomb, N = Newton, J = Joule.

---

Question 1.

The first diagram represents the situation in which a narrow beam of light (X) travelling through medium 1 falls on the plane interface between media 1 and 2, passes through medium 2 to point x on the plane interface between media 2 & 3 then continues along that interface.

The other two diagrams represent similar situations but with the beams (Y, Z) approaching medium 2 at two different angles such that Y and Z, then continuing to points y & z, respectively.

Which path does beam Y take after passing point y?

---

Questions 5 & 7.

Three bodies X, Y, and Z move along separate straight lines. Their positions (t times) are measured from a fixed point on each of their respective lines of motion at different times (t sec) and shown in the table below.

<table>
<thead>
<tr>
<th>Time (t sec)</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

Use the key given below to identify the type of motion of each body.

A: motion with constant, non-zero velocity
B: stationary
C: motion with constant acceleration (or deceleration)
D: motion with acceleration increasing steadily with time
E: some other type of motion

5. The motion of X
6. The motion of Y
7. The motion of Z

---

Questions 8 & 9.

A man whose mass is 70 kg is standing on the floor of a lift which is fitted with a meter to show the force exerted by the man on the floor of the lift.

The lift can move in any of the ways shown in the following key.

A: downward acceleration different from that of gravity
B: upward acceleration different from that of gravity
C: constant velocity
D: downward acceleration equal to that of gravity
E: upward acceleration equal to that of gravity

In the questions which follow, the readings of the meter on three different occasions are shown. Select from the key the motion of the lift which corresponds to the reading indicated.

2. 400 N
3. 300 N
4. zero.

---

Question 8.

The diagram represents a wire face directly above a centrifuge which is rotating at the same speed indicated above a vertical axis.

It changes its angular velocity from 20 radians per second to 40 radians per second at a steady rate.

Whilst this change is occurring the end of one of the arms of the centrifuge passes the point X, which of the vectors below best represents the acceleration of this end as it passes the point X?

---

Question 22.

The first diagram represents the situation in which a narrow beam of light (X) travelling through medium 1 falls on the plane interface between media 1 and 2, passes through medium 2 to point x on the plane interface between media 2 & 3 then continues along that interface.

The other two diagrams represent similar situations but with the beams (Y, Z) approaching medium 2 at two different angles such that Y and Z, then continuing to points y & z, respectively.

Which path does beam Y take after passing point y?
### Section 2

This section contains multiple-choice questions. Each is numbered (1, 2, 3, 4 or 5) on your answer sheet which corresponds to the alternative you choose in answering each question.

The items are grouped in the following way:

1(a) - 1(c) Electrostatics. Field, potential etc.
1(d) - 1(e) Current electricity. Resistance, power etc.
1(f) - 1(g) Electromagnetic, Induction etc.

### Section 3

This section will not be scored in the main test and is to be considered as a research test only. Nevertheless, please attempt the questions in the same way as you attempted Section 2 and do not be discouraged if you cannot answer them; they are difficult.

When you finish, please transfer your choices on to the examined cards provided.

### Section 4

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Symbols used in the items were those used in the course at the time, e.g., \( e = \text{Coulomb} \)

- \( f = \text{Newton} \)

### Level of Complexity

<table>
<thead>
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<th>Item</th>
<th>Key</th>
<th>Cuts</th>
<th>Apple</th>
<th>Grade</th>
<th>Cost</th>
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<td>D</td>
<td>(A)</td>
<td>1(C)</td>
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<td>2(A)</td>
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<td>3(j)</td>
<td>D</td>
<td>(J)</td>
<td>2(J)</td>
<td>C</td>
</tr>
</tbody>
</table>

### Notes

- **TEACHING POINTS**
  - A fast-moving electron enters a uniform electric field situated in a vacuum, the direction of motion of the electron being at right angles to the lines of force in the field. The motion of the electron in the field was similar to that of a stone falling freely towards the earth.
  - A freely falling body on the moon.
  - A motor car moving with uniform speed in a circle.
  - A bullet projected vertically upwards.
  - A bullet fired horizontally from a rifle.
  - A rocket projected vertically upwards.
  - A motor car covering with uniform speed in a circle.
  - A freely falling body on the ground.

### Diagram

In the figure above, \( E \) and \( E' \) are the electrostatic forces of two parallel plates and \( x \) and \( x' \) are the internal resistances of the cell. \( R_1 \) and \( R_2 \) are external resistances. \( E \) is the conventional positive end in the circuit with the direction shown. \( V \) is a voltmeter connected as shown. The voltmeter will read

1. \( E \)
2. \( E' \)
3. \( E \)
4. \( E' \)
5. \( R_1 - R_2 \)
APPENDIX 4

Questionnaire to Students (a selection of items)

UNIVERSITY OF SURREY
Institute for Educational Technology

From: James Kelly.

To: [Redacted]

June, 1970.

Dear (Friend),

The purpose of this questionnaire is to provide us with information which is not available in the I.E.T., nor has been asked for by myself during the course of the year. In fact it would take much longer to get this information by interviewing you.

I am going to ask you to do this when you do not want to forget your exams and just go on holiday, but it will provide us with most useful Information. You may think some of the questions pointless, or repetitive, but I assure you that the majority have been taken from other people's questionnaires and have provided important information.

The information will be completely confidential; your own questionnaire will go no further than myself, even to other members of the I.E.T., to which end I have provided an identifying number on the questionnaire. You will neither be identified, nor identifiable in any report I make on your study.

Some of the information asked for is factual, some about your motives, about the way you study, about the course, and finally a short test of mental ability which, if you examine it - please complete it immediately - even if you cannot see its value.

Many of the questions are True - False statements; for each of these statements, please indicate whether in general you agree or disagree with it by circling T (i.e. it is broadly true for you) or by circling F (i.e. it is generally false with regard to you). You may object that this is an unsatisfactory method of getting your opinions in which case please also use the space below each question for any other comments and reservations you have. Please make as many additional remarks as you wish.

Enjoy your holidays! I look forward to seeing you soon.

Best wishes,

[Signature]

5. Who gave you advice in choosing which universities to apply to?
- No one
- Parents/relatives
- Friends
- Teachers
- Careers matter/district
- Others - please specify

6. If you applied to other universities, please list these. If you were offered a provisional place or a flat place please tick.

Univeristy

subject

provisional place

firm place

(a)

(b)

(c)

(d)

(e)

(f)

7. List the subjects you wanted to study to O - level (or equivalent).

(SPACE)

8. If the subjects you actually studied at O - level were different from the above, please indicate the difference and the reasons for the difference.

(SPACE)

9. Please write a short account of why you chose to apply for the Physics B course.

(SPACE)

10. Who influenced you most in making the decision to apply for Physics B?
- No one
- Parents/relatives
- Friends
- Teachers
- Careers matter/district
- Others - please specify

11. Have you decided on your choice of career (however specific or general this is)?
- A if so this is
- B I am still hesitating about this decision, but I am considering the following courses:
- C I have no idea what decision I shall make about my future.

12. I have done my private study as follows (please tick)

- A in my own room
- B in other student's room
- C in the I.E.T. students room
- D in the Physics students room
- E in the University Library
- F in the common room
- G other (please specify below)

If there was any major change in the above during the year (e.g. due to change of type of residence) please describe this briefly.

21. I did most private study (ready notes, books, doing problems etc.)

- A in Maths/Physics/Chemistry
- B in another subject
- C in general

22. Approximately how much time do you spend studying on your own during term?

- None
- A very little
- B half
- C nearly all
- D very much

23. About how much of the time during vacations do you spend studying?

- None
- A very little
- B half
- C nearly all
- D very much

24. What sort of notes do you take in lectures?
- A Main points
- B Everything from the blackboard
- C Notes
- D As full as possible

25. Do you read scientific journals? If so please indicate which they are and how regularly you do.

3. Scientific American

- A
- B
- C
- D

4. New Scientist

- A
- B
- C
- D

5. Others, please specify

- A
- B
- C
- D

6. Use the code

- A
- B
- C
- D

7. Whilat at school I did think of becoming an engineer T F

46. A degree in engineering or science is just as useful for reaching the highest posts in industry and government service as one in History or economics T F

53. I tend to spend the right amount of time on each subject during the week T F

54. When written work has to be handed in I tend to leave it to the last minute and then often have to rush it T F

55. I find I cover the set material equally proficiently whether I find it interesting or not T F

56. After I leave now more from studying along my own line than through completing set assignments T F

57. Scaling the main topic in different tests only tends to confuse me I like to stick to one text T F

58. I am particularly interested in several topics that are outside my course work T F

59. I do not understand some of the material that is outside my course work

- A don't understandtramly
- B understand a little
- C understand moderately
- D understand very well

- 1 2 3 4 5

Taylors series
- A
- B
- C
- D

Hypothetical functions
- A
- B
- C
- D

Partial differentiation
- A
- B
- C
- D

Integration of (indefinite
- A
- B
- C
- D

Integration of (indefinite
- A
- B
- C
- D

Vectors
- A
- B
- C
- D
Dear Colleague,

Your association has very kindly allowed me to approach you to ask you some questions about courses which allow students with A levels, predominantly, or entirely, in Arts or Social Sciences, to obtain a Science or Technology degree.

I myself am a Schools Council Research Fellow studying the Surrey B courses, and it would help my research very much if you would help me to explore careers teachers' awareness of these courses and something of your attitudes to them.

I am fully aware of the pressures on you, particularly at this busy time and that these pressures will mean that you will hold prospectuses without knowing every detail of all the many courses offered in them. I have therefore kept the questionnaire as simple and as short as I could. I have enclosed a stamped addressed envelope for your convenience but please do not feel obliged to return the questionnaire if you are too busy or prefer not to.

I enclose details of the Surrey courses.

Yours sincerely,

[Signature]

For the purposes of this Questionnaire please consider the following groupings of subjects: (abbreviated to save space)

1. Science:
   - Mathematical subjects
   - Physical science subjects
   - Biological Science subjects
   - Engineering science
   - Geology
   - Technical subjects

2. Social Sciences:
   - British Government
   - Geography
   - Sociology
   - Economics
   - Accounting
   - Homecraft subjects

3. Arts:
   - English Literature
   - Historical subjects
   - Religious subjects
   - Art, Craft (design and practice)
   - Music
   - Classical and Modern Languages

All questions about students refer to those who had the hope of gaining a University place at some time during their sixth form course.

Fuller comments on the questions and related topics, other than the courses listed in 1 - 6, would help me to explore careers teachers' awareness of these courses and something of your attitudes to them.

Before you received this letter, were you aware of the possibility that students with "Arts" or "Social Science" A levels could embark upon a Science or Technology degree?

The questionnaire will be treated anonymously even if you wish to enter into correspondence on its subject.

Were you aware of the existence of any of the specific courses of this kind listed below? If so, please tick the more provided:

<table>
<thead>
<tr>
<th>Course</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Surrey University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Physics B</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>(ii) Metallurgy and Materials Technology B</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>(iii) Electrical Engineering B</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>(iv) Physical Sciences B</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>(v) Biochemistry B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. (i) North Staffs Poly Tech in Computing Science

3. (i) Keele Transfer Maths, Physics or Chemistry course

4. Preparatory or preliminary year at:
   (i) Aberystwyth (3 yr. Ord. BSc or 4 yr Hons)
   (ii) Bangor
   (iii) Birmingham
   (iv) Cardiff
   (v) U. M. I. S. T.

5. Bedford and other U. L. College Introductory Courses

6. Any other such courses (list these):

7. To the best of your knowledge, have any of your students ever followed any such transfer courses? Please give details:

   - (a) 1967 1 student

   - (b) 1968 2 students

   - (c) 1969 1 student

10. Other than these, do you know of students doing or having completed Arts or Social Science A levels, but who wished they had chosen one or more science subjects at the time:

   - (i) were doing well in their subjects
   - (ii) were not doing well in their subjects
   - (iii) had matriculated but failed to gain a university place?

11. Do you think students studying mainly Arts and Social Science subjects should be encouraged to consider applying for one of the courses listed in 1 - 6?

12. If so, which students: those who at the time:

   - (i) were doing well in their subjects
   - (ii) were not doing well in their subjects
   - (iii) had matriculated but failed to gain a university place?

13. Do you think any of your students in previous years might have been interested or well advised to consider such a transfer?

14. If so, were any of them, at the time:

   - (i) not doing well in their subjects?
   - (ii) already unsuccessful in their University applications?

15. Do you think you have any students taking A levels this year who might consider seriously the courses listed in 1 - 6?

16. Which subjects do you yourself generally teach?

17. When selecting their A level subjects do you think that students:

   - (i) generally have in mind a particular University subject?
   - (ii) on the whole are aware of the high degree of competition for places in Universities for certain subjects?

18. At your school, are students allowed to study Arts subjects with:

   - (i) Mathematics?
   - (ii) Physical or Engineering Science?
   - (iii) Biological Sciences?

19. Do you consider that, in practice, a Science or Technology degree:

   - (i) is more vocational than an Arts degree?
   - (ii) has as great a general educational merit as an Arts degree?

20. If so, please tick the more provided:

   - (a) Grammar
   - (b) Public
   - (c) Comprehensive
   - (d) Other

21. Approximate number of pupils in the whole (i) GS system (ii) GS system this year:

22. Approximately how many of your pupils go to University each year:

   - (i) Under 10
   - (ii) 10 - 20
   - (iii) 20 - 40
   - (iv) 40 - 60
   - (v) Over 60

   (If you can estimate these more exactly this would be appreciated)
Notes on the use of the Mann-Whitney test.

In testing the significance of differences between examination scores of subjects who fall into two groups, the most obvious tests to apply are the t-test and the F-test. The assumptions of the t-test are:

1. the scores are normally distributed for both groups
2. the variances of the scores are the same
3. for the null-hypothesis, the means are the same
4. that the scales are interval scales.

Notes on the use of the Mann-Whitney test

For small samples in a test population, it is not possible to test the normality of the distributions, but in many instances, the distribution of scores in the control population has often differed markedly from normality (Figure 10). In practice, variances of groups are normally combined to give an unbiased estimate of the 'true' underlying variance assuming the null hypothesis, the Cochran-Cox method used in this work, is close nearly like that of normal scientific tests. In addition, it violates the second assumption in order to assess differences where distributions have unequal underlying variances.

The assumption that examination marks are assessed on an interval scale is, perhaps, the most disputable assumption. This implies that differences of, say, 5 marks are equivalent at whatever point on the scale they occur. In practice, tests are marked so that different abilities are called for at different points on the scale. Thus, typically, marks at around the pass mark of an examination may be gained by recall perhaps with a little comprehension, whereas distinction marks are gained when higher abilities are called upon. Further, teachers often make the implicit assumption that these scales are ratio scales.

In using non-parametric or distribution free tests, these assumptions are not made. In using the Mann-Whitney U-test, for example, the only assumption made is that generally, a higher score in an examination implies, in general, greater knowledge or understanding than a lower score. Thus, using the rank of a student in a class makes no assumption about the distributions on the scale, which is assumed to be ordinal.

The power of this Mann-Whitney test, as compared with the t-test where the latter's more restrictive assumptions are satisfied, is however ~95%. It can, however, be more powerful where these assumptions are not satisfied.

It is an extremely easy test to use in practice. The null hypothesis is that the ranks and therefore the scores of the test population are distributed in the same way as those of the control population. That is, if the number of subjects \( n_1 \) in the control set scoring higher than each of the members of the test set in turn is counted, on average, this will be half the number in the control set. That is, if \( n_c \) is the number of subjects in the control set, on average \( \frac{n_c}{2} \) subjects will score more highly than each of those in the test set.

If these counts \( n_1 \ldots n_i \ldots \) are summed over all the members of the test set (total \( n_t \)) then the expected value of this sum will be \( n_t \times \frac{n_c}{2} \).

That is \( \sum n_i = n_t \times \frac{n_c}{2} \).

This may be seen diagrammatically. If each score in the control set is seen as defining the limits of a 'box', then the probability (in the null hypothesis) of a score in the test set falling into any box must be the same for each box.

A programme to test the power of the Mann-Whitney test against the two versions of the t-test mentioned for a variety of distributions and a difference generally of one standard deviation between population scores was developed by the author. Preliminary results indicate that for the restricted range of distributions and differences explored, the t-test (in which variances are combined) is more powerful than the Mann-Whitney test, which in turn is more powerful than the Cochran-Cox t-test.

For this purpose, a tie is counted as \( \frac{1}{2} \).
Some Components of Evaluation

'To evaluate' is variously defined as:

- to work out the value of
- to find a numerical expression for
- to reckon up or ascertain the amount of
- to express in terms of the known
- to appraise i.e. to fix a price for
- or to appreciate or estimate in respect of excellence or merit or moral or aesthetic value or worth

'value' itself is variously defined as:

- amount represented by a symbol
- precise meaning
- material or monetary worth or price
- fair or adequate equivalent
- that which renders anything useful or estimable
- the degree of this quality
- efficacy
- worth, relative worth, high worth, excellence, esteem
- intrinsic worth or goodness
- recognition of such worth
- relative status or estimate according to real or supposed worth, usefulness or importance

Whilst there is a strong emphasis in these definitions on the quantifiable and presumably objective, there is equal weight given to the subjective, e.g. 'esteem' includes to attach value (subjectively) to, 'estimation' includes the process of forming a notion of without using precise data, and opinion and judgement.

In an educational context then, evaluation would be a complex of appraisals of a course, against criteria ranging from the quantifiable to those involving judgements. One component would be to provide such information as to be helpful in the making of educational decisions. Such decisions as whether or not to mount the course, what population to select and criteria for selection, what the goals of the course should be, how to change the course better to achieve the goals are but a few examples.

1 Shorter Oxford dictionary
2 Oxford Etymological dictionary
3 Chambers's 20th Century dictionary
4 Concise Oxford dictionary,
13.1 In this experiment you will need to use an oscilloscope, signal generator, two loudspeakers and a microphone. Start by adjusting the oscilloscope. Switch it on and tune up the amplitude so that the screen is filled with the signal. Your display should now be instantaneous and as the time-base is starting off automatically. In this experiment you will need to start off at a fixed point relative to the signal given to the loudspeakers without tuning the signal. Once you can see the signal, put the signal generator on the oscilloscope terminal and select E(I) or E(normal) trigger mode using the appropriate switch. Do this. Adjust the trigger level control so that the time-base triggers. Check that the time-base does trigger at the proper time by connecting a lead from the external trigger terminal to the Y input terminal. Is the trace stationary i.e. repeating the same thing each time it occurs? (If not, consult a demonstrator). Gradually reduce the amplitude of the signal, adjusting the trigger level control as you do so to eliminate any trigger. This is because you may annoy other people and will need to produce as little sound as possible.

13.2 Now connect two loudspeakers in series to the 510 terminals of the signal generator. Connect the microphone to the Y input of the oscilloscope (with the outer conductor or screen connected to the earth terminal). Select a suitable position for the V olts/cm switch; turn up the * A mp before m u ltiplier on the scope and clump the microphone to the Y input terminal. Line up the two loudspeakers as in the diagram and clamp the microphone so that you can move away to reduce the effect of reflections from your body.

13.3 Move the microphone (which should always be directed at the point midway between the loudspeakers) about an arc centred on this midpoint. Find one position near the inner of the system, where the vibrations detected by the microphone are greatest. Measure the separate distances from each source to the microphone i.e. the path lengths of each wave. What is the difference between these lengths? What predictions can you make about the two oscillations interfering at the two sources and detected by the microphone?

13.4 Check this prediction by covering up each loudspeaker in turn and examining the phase of the two oscillations detected relative to each other. (Assuming that the microphone measures a zero voltage when it is not in phase, do the two total waves produce the same pressure change at the microphone? Are these in phase?)

13.5 Repeat 13.3 and find a new position of maximum vibration. Do the conditions of 13.4 hold at this position?

13.6 Now move the microphone along this line by such a distance that the oscillation displayed on the oscilloscope changed in phase by one complete cycle. What is the wavelength of the oscillation?

13.7 Move the microphone away from the axis until the detected signal is a minimum. S eparate the separate signals from the two loudspeakers.

What can you say about the pressure changes produced at the microphone by the two loudspeakers. Measure the separate distances travelled by the two waves from the two loudspeakers, but fraction of the wavelength is the difference between these path lengths? Relate this to your observations on the way the pressure changes at this point and to the pressure changes caused separately by the two loudspeakers.

13.8 Move the microphone further away from the axis until you find another position where the detected signal is a maximum. Repeat the study of 13.7.

13.9 Disconnect one loudspeaker and direct the other as a reflector, explore whether or not there is interference of the wave received by the microphone direct from the loudspeaker and that received after reflection.

13.10 Direct the loudspeaker at a wall or hardboard reflector situated about 3 m away.
Appendix B

Sample items from Course evaluation questionnaire

AIMS QUESTIONNAIRE 1

Please describe the next important things you have gained from attending the course, in terms of knowledge, skills and attitudes.

Please describe
(1) what you feel the course has not been able to do for you which you would have liked
(2) what the course did for you which you did not like.

AIMS QUESTIONNAIRE 2

The aims listed are based on statements by University teachers and could be considered as possibly attainable for a course for new teachers in Mathematics, the Sciences and Technologies in Universities and Polytechnics.

1. Please rate the importance you think was actually given to these aims in the course, using the scale

<table>
<thead>
<tr>
<th>Importance</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>No importance</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Very important</td>
<td>5</td>
</tr>
</tbody>
</table>

2. Please rate how well you think the course achieved these aims for you, using the scale

<table>
<thead>
<tr>
<th>Achievement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Very well</td>
<td>5</td>
</tr>
</tbody>
</table>

Please feel free to make comments on these aims on the facing page.

It would help somewhat in rating the second scale independently of the first if you were to go down the complete list of aims for importance first; thus you might be more ready to give a high rating on achievement to an aim which, though unimportant in your view, was achieved very well for you.

AIMS QUESTIONNAIRE 3

Overall is a list of terms, methods and techniques which might be appropriate to the teaching of some subjects in Higher Education. I should like to know something of your interest in trying out some of these at some time in the future (as a method of teaching or as a technical aid in designing your teaching as distinct from subject matter of your teaching).

For CAT each item of which you are aware please indicate your interest in the development toward application of it to your own teaching, by circling:

0...if you don't know
1...if you think you definitely will not use/applicable knowledge of it in your teaching
2...probably will not
3...probably will
4...definitely will
5...definitely will

For the SUE items please indicate the extent to which you feel they should be brought into an initial course by circling:

1...If you think it is should not be mentioned at all
2...should be mentioned briefly
3...should be gone into in some detail
4...should be well-experienced in the course
5...If you think course participants should be actively involved by using

In asking this, I am not suggesting that the course necessarily mentioned

Aims in the course

Achievement

Please rate only those which you feel you have heard of, if used.

Please go completely through the list for each scale separately.

<table>
<thead>
<tr>
<th>Importance</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>Scale</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
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<tr>
<td>1</td>
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<td>3</td>
<td>3</td>
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<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Aims in the course:

1 course aims and objectives
2 student objectives
3 affective objectives
4 cognitive objectives
5 taxonomic objectives
6 evaluation instruments
7 facilitative evaluation
8 summative evaluation
9 test reliability
10 test validity
11 multiple-choice questions
12 item banking
13 item analysis
14 concept formation
15 disjunctive concepts
16 open-ended experiences
17 Keller plan
18 brainstorming
19 group groups
20 syndicate method
21 free group discussion
22 spectacles
23 student-centred learning
24 simulation
25 gaming
26 overlays
27 library as media resources centre