A STUDY OF THE RELATIONSHIP BETWEEN SOME OF THE
COGNITIVE AND CONTEXTUAL FACTORS IN STUDENT LEARNING.

by

D.M. LAURILLARD.

University of Surrey.
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The study of the phenomenon of learning has attracted psychologists and educationalists for many years as an interesting and challenging problem. Learning as it is practised at the level of higher education has been less widely investigated, however. At this level it is a highly complex cognitive activity that does not easily reduce to well-defined experimental learning situations. For this reason, the thesis takes a holistic approach to the study of learning which sees learning as an activity which is related both to the subject-matter content of a learning situation and to the contextual factors that surround it.

The study is based on previous research work within each of these areas, in an attempt to define the important factors that influence a student's approach to his study, and to establish the nature of the relationships between them. The research methods used have in part replicated previous research, and in part extended the application of these methods from experimental learning situations to real learning situations, i.e. to learning tasks that students engage in as part of their academic coursework.

By considering a series of case studies of students working on several different learning tasks, it is possible to show that a student's approach to a task depends to some extent on his perception of that task, and on his perceptions of the circumstances within which he is doing it. The students are not easily categorised as adopting one particular learning style consistently, instead they are responsive to the conditions of the particular task in determining the form of their approach. This is the argument of the thesis: that student learning styles are both content- and context-dependent.
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The thesis presented here may be very briefly summarised as follows: "There are some cognitive aspects of student learning that can be shown to be influenced by the students' response to contextual factors in the teaching-learning process." The terminology used in this summary needs to be explained more fully at the outset.

"Student learning" refers to the kind of high-level learning activity students engage in when they are trying to understand their subject. The nature of this type of learning is not specially defined: it is studied in terms of its common usage meaning within academic life, and is not defined beyond that. The students are undergraduates in science and technology.

The "cognitive aspects" of student learning are ways of describing the constituent activities of learning that have already been identified by some researchers.

The "contextual factors in the teaching-learning process" refer to those aspects of teaching, assessment, and subject matter that this research shows are important for an understanding of student learning.

Thus the overall aims of the thesis are (a) to show that there is a relationship between the cognitive and contextual aspects of learning, and (b) to explore the nature of this relationship.

A fundamental aim, throughout the research study, has been to provide an account of student learning that will be useful to teachers and students in the practice of teaching and learning. This is perhaps more accurately described as an ideological stance than an aim, because it is an ambitious
aim, and one that is hard to achieve within the life of a single research project, given its starting point. At the beginning of the research study, the literature on student learning provided a number of potentially useful theoretical concepts from the psychological approach to the study of learning, and a powerful but innovatory research methodology from the field of educational evaluation. The starting point of the research therefore combined a replicatory study, based on previous theoretical studies and using their methods with an exploratory study that incorporated the more flexible approach of educational evaluation. It was this early combined study that defined the original aim of the research as being to establish the nature of the relationship between cognitive and contextual aspects of learning.

This overall aim has been fulfilled and forms the main body of the thesis. The end result, however, is perhaps more a basis for further research than a tool for immediate use by teachers and students. The possible relationship between this end point and a study that is of direct practical value is discussed in Chapter 7. Thus the ideological stance remains, but the fundamental aim is longer term than the scope of this thesis.

Summary of Chapters

The survey of the literature in Chapter 1 covers some of the research areas in the fields of psychology, educational psychology, and education, that have investigated aspects of learning and teaching. This is necessarily selective as the fields are wide ranging and many different types of study are at least peripherally relevant. The criteria for selection are discussed at the beginning of the chapter. The first section discusses some of the theoretical models of learning that have been developed to describe how learning occurs within the individual. These models apply to all individuals. The next section considers a contrasting approach that looks at the differences
between individuals' ways of learning. Finally, a different approach again, is to consider learning in relation to teaching, as an activity that does or does not occur as a result of the teaching. The three different types of approach to the investigation have different research methodologies because they are tackling the problem in quite different ways.

The relationship between the nature of the research problem and the methodology appropriate to it is discussed in Chapter 2. Recently several educational researchers have expressed dissatisfaction with aspects of the traditional methodology of educational research. In particular, they find that much of the richness and complexity of the educational process is lost to researchers who, for example, confine admissible data to the quantitatively measurable. The kind of methodology that requires this is seen as counterproductive, and has led to the development of more flexible, qualitative research methods that are better adapted to capture the complexity of the educational process. Chapter 2 compares these two approaches and discusses those aspects of the latter that are particularly appropriate for the research problem defined. This is developed from two of the most promising aspects of current research on learning: to explore the relationship between the students' response to the content of their work and to the context within which they work. It is this exploratory nature of the problem that requires a methodological approach that is more flexible than the traditional quantitative approach.

Chapter 3 outlines the various methods and techniques used throughout the different stages of the research. These included replications of techniques used in laboratory based research studies, adaptation and extension of the same techniques into situations based on students' normal academic work, and exploratory studies that used mainly open-ended interviews with students about their perceptions of their work.
Chapter 4 describes the attempts to replicate four research studies by Bruner et al, Thorsland & Novak, Marton and Parlett. This formed the pilot study for the main body of the research which was developed from the relatively greater success in replicating the work of Marton and Parlett.

The main part of the study, described in Chapters 5 and 6, is divided into an analysis and synthesis of the data. The hypothesis generated by the pilot study was that individual differences in student learning which had been identified by researchers such as Ps&k and Marton, did not discriminate well between students. These descriptors were applicable to students' accounts of their learning, but in a way that discriminated between particular learning situations (i.e. the student in a particular teaching-learning context) rather than between different students. The evidence for this is analysed and presented in Chapter 5, and the relationships discovered are synthesised into an overall model of student learning in Chapter 6.

It should be emphasised here, as it is throughout Chapter 6, that this model serves as a tool for the development of the research. It is a convenient way of summarising the data and helps to clarify the relationships postulated. It is necessarily incomplete, as a single research study cannot expect to exhaust a holistic account of the teaching-learning process. But its value lies in the fact that it makes conspicuous any incompatibility with other research results, and by making explicit the relationships hypothesised, enables further research to build systematically on this tentative beginning.

Thus the end point of this research study is more likely to lead to future research than to be used directly by teachers and students. The thesis concludes with a final chapter discussing this point and suggesting some of the ways in which a future study could bridge the gap between the theoretical model hypothesised and results that could be of direct practical value to the practitioners of teaching and learning.
1.1. Introduction

The problem of learning has been investigated in a number of different ways by researchers working within several different disciplines. The educational practitioner who wishes to design materials on the basis of research findings might find himself delving into such disparate fields as cognitive psychology, educational technology, artificial intelligence, cybernetics, educational psychology, child development. All these are relevant to learning, all can claim to address themselves to the investigation of problems of learning, but few have provided well-established guidelines for the practising educator.

In part this is undoubtedly due to the nature of the problem. It is sufficiently recalcitrant that probably no active researchers in the field would now envisage a universal Theory of Learning as they did in the early days of the behavioural theories. The establishment of guidelines for the educator is a more feasible objective, and indeed some psychological theories of learning have already provided the basis for the development of educational materials. These have generally been oriented towards lower-level learning activities however and are not so relevant for those educators who wish to assist student learning at the university level.

The use of the word 'learning' is problematic here. For the academic, it refers to a mental activity that the student actively engages in, whereas for some learning theorists it is a descriptor for an activity that takes place whenever a change in behaviour occurs. This is not sufficient for the educator who needs a model of how the student operates in response to a particular teaching situation. For him learning does not occur as the inevitable result of the correct manipulation of certain observable variables.
Instead it occurs as the result of such esoteric activities as thinking, reasoning, evaluating etc. Thus, in an academic context, learning is not seen as a change in behaviour; it is itself a behaviour and one that is highly problematic and worthy of investigation.

Bearing in mind that the educator is interested in this special sense of learning as a complex cognitive activity, we may now examine the literature to discover those areas of work which are relevant to this.

The wide range of subject areas that can offer useful ideas and techniques may be categorised according to the approach they take to the investigation of learning. One approach is to consider the nature of the human mind, taking as a basic assumption that all human minds operate the same way, within certain limits, and that a cognitive model of learning will therefore explain all human learning that falls within those limits. A second approach is to consider how individuals differ in their approach to a learning situation, and therefore elicits characteristic learning styles of individuals. The third approach is to consider the effects of different teaching methods and distinguish between these according to what is learned as a result.

The reason for selecting these approaches is that they must all say something about high-level, meaningful learning of the kind found in higher education. This is not the case for some areas in the psychology of learning, such as information processing, behavioural psychology, developmental psychology. All these have been omitted from the following survey because they focus on low-level learning, or as in the case of information processing, predominantly on memory. These are certainly components of high-level learning, but they are not the most important ones. It is possible that the theoretical findings in these areas may ultimately contribute to the development of research in
higher education, but at this stage it seems prudent to confine the survey to those areas in the study of learning that have immediate relevance to higher education. The teacher needs an account of learning that will help him to operationalise his interaction with the student successfully, both in the presentation of subject matter, and in the design of learning activities for the student.

The following sections summarise some of the major work in each of the three areas outlined above, and consider their relevance for the practising teacher in higher education. The aim of the survey is to select those areas of the research literature that can form a basis for the research presented in this thesis. With this in mind, I have considered the relationship between the nature of the methodology, and the nature of the research findings. This kind of analysis necessitates a detailed discussion of a few studies rather than a brief survey of many. For this reason I have tried to select for discussion major studies that are representative of the various types of approach and outcome.

1.2. Theoretical Approaches to Learning

Historically, theories of learning have provided little practical help to teachers other than some concepts, and vocabulary with which to consider the process of the acquisition of knowledge or change in behaviour. Psychologists were interested in studying the occurrence of learning rather than the promotion of it and their research has therefore been slow to produce guidelines or even hints for practising teachers.

"Despite half a century of research and the development of several sophisticated theories, the teacher's classroom activities have been relatively unaffected by what the learning theorist has to say." (Jackson, 1958)
Gage (1963) makes the point that education needs a theory of instruction rather than a theory of learning:

"To satisfy the practical demands of education, theories of learning must be "stood on their head" so as to yield theories of teaching".

In recent years this has happened, although not literally. Theories of instruction have now been developed but not with reference to the former learning theories so much as to the practical experience in the classroom. There are now theoretical approaches which are oriented more towards the problems of the particular type of human learning which is confronted at classroom level. As theoretical approaches to learning became the province of educational psychologists, so their relevance to education became more apparent.

The use of the word 'theoretical' is important here as theories of instruction, however practically oriented, are still related to a theory of learning. Ausubel (1968) argues that a theory of instruction alone is a waste of research time and effort if it does not relate to laws of learning. These laws will not generate detailed teaching principles, but they will indicate the general directions for discovering effective teaching methods. Thus "theories of learning and theories of teaching are interdependent rather than mutually exclusive .... Theories of teaching must be based on theories of learning but must also have a more applied focus" (Ausubel 1968).

The applied focus is important if research in educational psychology is to be potentially useful, as the generalisations derived from fundamental theory are not operationally defined at the classroom level. It is not possible to extrapolate from laboratory findings on a particular well-defined type of learning to the qualitatively different kinds of learning found in the classroom: "although the use of nonsense syllables adds undoubted methodological rigour to the study of learning, the very nature of the material limits the applicability of experimental findings to a type of short-term
discrete learning that is rare both in everyday situations and the classroom."
With all the problems that applied research presents, such as the research design, control and measurement, educational psychology needs to adopt this approach if it is to be useful in education.

By 'applied research', however, Ausubel means research that "actually takes into account both the kinds of learning that occur in the classroom as well as the salient characteristics of the learners". It is the orientation that is different; the methodology is often similar to basic-science in that research studies are done outside the classroom. The approach Ausubel takes, therefore, is to argue that educational research must investigate the types of learning that are common in the classroom, such as verbal learning or concept acquisition, and that this must be done on the basis of evidence from existing learning theories and research generated from them. Accordingly, the contribution he makes to educational psychology is to present general guidelines to teachers indicating areas within which particular operations can be developed, all this being couched within a substantial theoretical framework with supporting evidence drawn from psychological research.

The basis of the theoretical framework is the concept of 'meaningful reception learning'. The majority of school teaching is expository, so the complementary form of learning must account for the acquisition and retention of subject-matter knowledge via the medium of language. It is this capability of human learning that allows a child to acquire a large repertoire of concepts and principles that would not be possible if they all had to be empirically experienced, or 'discovered'. The importance of meaningful learning is demonstrated by research findings such as Katona's (1940) that a meaningfully learned solution to a hard problem was more effective than a rote-learned solution.
The mechanism by which meaningful learning takes place is described in terms of a theory of subsumption. New information is meaningful when it can be related to existing components in the cognitive structure, and this relation aids retention. This has implications for a theory of instruction which is illustrated in Ausubel's 'advance organisers'. If a teacher wishes to introduce new material, then the theory suggests that he should first provide the general concepts or principles, i.e. the advance organisers, under which the new information can be subsumed. The full theoretical framework gives an elaborate account of the different kinds of subsumption and their relation to a hierarchical cognitive structure.

There is no doubt that Ausubel's approach is applied in the sense that it can generate general guidelines for practical teaching. The theory itself, however, is supported by evidence from experimental psychological research, and therefore attends to the nature of human learning, and not to the reality of learning activities in the classroom. The theory bears the same kind of relationship to classroom activities that the laws of physics bear to the building of bridges: they may well describe some of the general features of the situation, but they do not claim to operationalise the practice.

A similar approach to the problem of learning is taken by Gagné (1977). It is similar in the sense that it provides a theoretical model for the nature of human learning, and insofar as it has implications for the practice of education. Once again much of the evidence for the theory rests on experimental findings in educational psychology.

Gagné defines a hierarchy of types of learning which is grounded in the basic types familiar in psychological theories of learning such as signal learning and stimulus-response learning, and develops from these into higher order types of learning such as concept learning, rule learning and problem-solving.
One of the reasons for defining such a classification is the need to differentiate between the many different types of learning:

"A serious attempt to describe learning must take all these varieties into account. Naturally it must make differentiations among them, and classifications of them, if these are possible. But to begin with the premise that "all learning is the same" would be quite unjustifiable". (Gagné 1970)

It is Gagné's intention, in differentiating the various types of learning, to establish the conditions under which they may occur. The hierarchy helps to define these conditions as each type of learning is a necessary pre-requisite for the successive type in the hierarchy, e.g. problem-solving is only possible when the learner has the necessary rules and can recall and apply them. In addition to these internal conditions, Gagné also describes the internal conditions that must be provided within the learning situation e.g. in problem-solving, the instruction should provide aids to the recall of relevant rules, and cues to guide thinking.

In this way, Gagné's model is capable of providing quite detailed guidelines to teachers as it defines the optimal structure and sequencing of instructional material. In defining the conditions of learning and the cognitive activities involved in each type he is able to describe how learning and teaching can operate together successfully, but he does not describe, for example, the individual responses of the learners. He does acknowledge the existence of individual differences in problem-solving but "the major emphasis has been ..... on those factors that are essential for problem solving, regardless of how individuals may differ". Differences arise from the facility an individual has in the performance of the constituent cognitive activities, and hence the time he takes to solve a problem.

The experimental studies of problem solving can be interesting for teachers in higher education because the level of complexity of thinking required for
this kind of cognitive activity comes closer to the type of thinking confronted in higher education than many other activities that have been the focus of research in educational psychology. The study of problem solving has a history quite separate from the study of learning, as it had its roots in gestalt psychology and the study of thinking rather than the behavioural psychology that formed the background to learning theory. Maier (1930), Koffka (1929) and Wertheimer (1959), for example, have studied problem-solving as a form of productive thinking. The research method was to make an observational study of humans solving complex problems and to build from this an account of how problem-solving operated, as a reasoning process. It is in this sense that the study of problem-solving could be of interest in higher education where students are engaged in complex reasoning when they are learning.

When problem-solving became linked to educational research in the work of Gagné (1964), Kendler (1964) and Rothkopf (1965), however, it was not focused upon as a form of reasoning in its own right, but as a form of learning. For Gagné, problem-solving consists of a series of activities such as defining the problem, formulating hypotheses and verifying the hypotheses. After problem-solving behaviour of this type has taken place, an observable change in behaviour occurs, then learning has taken place. Hence problem-solving is a form of learning. (Gagné 1964). Polya (1957) outlines a similar heuristic procedure for problem-solving, the main elements of which are: understand the problem, devise a plan, carry out the plan, examine the solution. The approach here is to study the problem-solving process in isolation from the nature of the problem or the characteristics of the solver, which is very different from e.g. Wertheimer's more introspective, humanistic approach which describes the thinking involved in terms such as: realising structural features and requirements, changing the situation in the direction of structural improvements, separating structurally peripheral from fundamental features. (Wertheimer 1959). The perspective that Gagné takes
is characterised in Kendler's observation that it is sensible to link problem-solving to learning as we know so much about learning that this will aid the study of problem-solving. Gagné's work is based ultimately on S-R theory which suggests that he sees the study of learning as a far more tractable problem than would researchers in classroom-based learning.

Rothkopf's work is important for his definition of the theoretical concept of 'mathemagenic activities'. These are defined as

"Those student activities that are relevant to the achievement of specified instructional objectives"

literally: activities that give birth to learning. The theoretical value of this concept is that if these activities can be identified, then teachers can operationalise the objectives of their teaching in terms of the activities the students should be doing. This contrasts with Gagné's approach which stipulates the conditions to be fulfilled by the teacher under which certain student learning activities necessarily take place. The kinds of activities examined by Rothkopf, however, are relatively low-level, such as: selecting appropriate instructional material, paying attention to instructional material, scanning material, translating into internal representations etc. The most interesting from the point of view of learning in higher education, are the covert activities such as translating into internal representations but much of the work that has followed from Rothkopf's (e.g. Rothkopf 1966, Frase 1967, Rothkopf and Bisbicos 1967, McGaw and Grotelueschen 1972) has focussed on the various teaching strategies that can be used to encourage mathemagenic activities, such as the use of questions within written text. While this research has useful implications for self-instructional texts it has not contributed to an account of how students learn in actual learning situations.

In a comprehensive study of this field, Nelsson (1976) has pointed out:

"The question of how the student might influence his instructional environment has however been neglected in the Mathemagenic activities experiments. Therefore the main omission in the Mathemagenic activities research has been the analysis of the situation. The frames that steer the options available to the students in the teaching situation have
not been taken into consideration. The fact that teaching is a
social activity, and that education is a societal matter, has not
been realised. Therefore, it has also been possible to continue
investigating the questions of mathemagenic activities, and
arrangements steering them, as only psychological matters.
They are not".

While the concept of 'mathemagenic activities' is a useful way of describing
aspects of student learning, the research in the field is in the behavioural
tradition that learning is a behaviour that can be manipulated, rather than
a cognitive activity that resides within the student.

The reason for grouping together these particular research studies on
problem solving and learning is that they represent a particular approach.
The approach in all these cases is to characterise the nature of human
learning as it must necessarily operate. They make the basic assumption
that the human mind operates in a particular, characteristic way when it
learns, thinks, solves problems, and that this is discoverable by suitable
research methods, and once discovered may be used to derive appropriate
teaching methods. The theoretical descriptions obtained are in all cases
derived from experimental laboratory-based research and are therefore oriented
towards a definition of 'the way things can be', rather than a more complicated
description of 'the way things are'. The value and significance of such an
approach is that it provides a way of articulating a rational approach to
education; it provides a good rationale for the way a curriculum should be
structured, for the way a topic should be presented, for the types of
activities students should engage in. Complexities occur in the form of
e.g. individual differences in pre-requisite capabilities or in the time taken
for a particular activity, but all individual responses can be accounted for
in terms of the general description of the way human beings learn. Whether
there are fundamental differences between human beings in the way they learn,
is not provided for within this type of approach.
Because this approach does not accommodate a description of the complexities of the practice of teaching and learning, I have not used these studies as a basis for the research presented in this thesis. It is more appropriate to return to the theoretical ideas generated by this approach at the end of the thesis. They may be able to clarify the synthesis of the more complex results obtained by the less theoretical approach of the research described in later chapters.

1.3. **Individual Differences in Learning**

The literature of educational psychology is rich in studies of individual differences, but may be reduced to the particularly relevant subject that considers variation in types of thinking, rather than variables such as race, class, sex, personality etc. The types of thinking may include both styles of learning and strategies of problem-solving, but the basic assumptions that are common to all of these studies are that (i) there exist different types of thinking, and (ii) there are individual preferences for these different types. The aim of this section is to discuss several studies in relation to their methodology, in order to establish those that provide a suitable basis for the research study presented here.

One of the early, more influential studies of this kind was Getzel's and Jackson's research on Creativity and intelligence (1962). The aim was to differentiate between creativity and intelligence by using a range of tests appropriate for the two different types of thinking. The types of thinking are themselves defined in terms of the tests used to measure them i.e. open-ended tests of the form 'How many uses can you think of for a brick', and standard I.Q. tests. Thus children were rated as 'high creative' or 'high I.Q.' according to their differential scoring on the two types of test.
One of the major problems with this type of study, as Hudson (1966) points out is that correlations between scores, on the creativity tests particularly, are often very low. In his own study, which redefines the categories according to Guilford's (1956) terms as 'convergent' and 'divergent', he states:

"The fact is, then, that a boy who is a diverger (or converger) on one set of tests may not be so on another set".

The effect of both these studies is to classify children as being significantly higher scorers on one type of test than on the other. Inevitably such a classification forms a distribution within which the largest group scores approximately equally on both types of test. The conclusion can be drawn, therefore, that individuals differ in the extent to which they prefer one type of test to the other. The range of the difference is not discussed, neither is the extent to which individuals are capable of being versatile, in spite of the statement quoted above. As the tests themselves are highly specialised, it is difficult to relate them to the kinds of tasks a student normally confronts. Hudson demonstrates that Arts students tend to be divergers, science students tend to be convergers, but apart from describing them in general terms such as response to logical argument or human affairs, he does not attempt to characterise these "styles of reasoning" in terms of the cognitive activities required of the two types of student.

This type of dichotomy is somewhat artificial in that it occurs as a result of differential responses to different types of standard test. It happens that the dichotomy correlates with the arts/science dichotomy, but it is hard to draw any implications from this. The fact of the correlation suggests that the tests do reflect a genuine bias in some individuals, but it has neither theoretical background, nor practical application. Further studies (Hudson 1968) showed that the students' perceptions of the task had an important effect on their performance. One of the characteristics of the
divergent is that for the 'uses of objects' test, he produces a large number of inventive answers. When students were shown an example of a diverger's answers convergers also produced 'divergent' types of answers: "The converger, in other words, is not so much the boy who cannot think divergently, as the one who thinks fluently only when told unambiguously to do so" (Hudson 1968). Hudson suggests this may indicate a more basic difference in response to authority. This point is related to a study of syllabus-bound and syllabus-free students, by Parlett, which will be discussed later in this section.

An alternative approach to the problem of individual differences in thinking is to hypothesise the existence of a particular dichotomy, and then devise a single set of tests that will discriminate between individuals according to the strategies they adopt. The basis for the hypothesis may differ from study to study, and the fields of study are also different, although the basic methodological approach is the same.

Witkin's studies on field dependence and field independence were based originally on laboratory experiments, but subsequently developed into an analysis of cognitive style that could be related both to other similar studies and to the practice of education. Field dependence/independence is defined as "the extent to which the person perceives part of a field as discrete from the surrounding field as a whole, rather than embedded in the field" (Witkin 1977). Thus a field dependent person is dominated in his thinking by the prevailing field, whereas the field independent person perceives items as more or less separate from the surrounding field. This dichotomy of perceptual style demonstrated in the early laboratory experiments was later shown to be equally applicable to intellectual style, as further research established the correlation between this and intellectual characteristics such as Duncker's (1945) functional fixity. As research progressed, it was possible to build up a number of characteristics of cognitive styles
that could be subsumed under the general descriptors, field dependent and field independent. One of the most interesting sets of characteristics, because of its relevance to practical education, is the individual's approach to organizing and structuring a field of knowledge. When material to be learned is structured in advance, there is no difference in learning between the two cognitive styles. Unstructured material, however, discriminates between the two, because the field independent students can impose their own structure by using an internal frame of reference, or 'mediator'. The mediator itself has a hypothetical status, based on the theoretical assumptions about the nature of the field dependence/independence dichotomy. The studies that Witkin cites in support of the use of mediators by field independent subjects, certainly demonstrate that field dependent subjects benefit from external structuring of material and perform worse with unstructured material, but they do not investigate the nature of the mediators. One of the studies he cites that does suggest the nature of the mediators used is the study of concept attainment by Bruner, Goodnow and Austin (1956).* Here they studied the hypothesis testing model of concept attainment showing that subjects differed in the way they used hypotheses to organise their strategy of concept attainment. This study does not discriminate between subjects according to the field dependence/independence dichotomy, however, and moreover analyses the data to show that all the subjects use some form of hypothesis testing approach. To adduce this study as evidence for the hypothesis as a form of mediator therefore raises questions about the validity of the dichotomy, unless it be supposed that all Bruner's subjects happened to be field independent.

A safer piece of evidence comes from a study by Kebelkopf and Dreyer (1973) which used a concept attainment exercise to demonstrate a correlation.

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* This study is discussed in more detail in Chapter 4.
between field independence and a hypothesis testing approach, and between field dependence and a passive spectator approach*.

The field dependence/independence dichotomy is well-documented as a perceptual phenomenon. As an intellectual phenomenon, Witkin has cited studies that demonstrate differences in types of reinforcement that are effective, the use of mediators and cue salience. All these have practical implications for suitable teaching strategies although some of the evidence here is a little more shaky than in the perception studies. One of the conclusions from the study of the dichotomy as related to career choice, is that all science and engineering students can be expected to be field independent. The value of this work for the present study, therefore, is that it defines some of the possible parameters of the cognitive style of the students, i.e. that they respond to intrinsic reinforcement, that they use mediators of some kind as advance organisers, and that they respond to non-salient cues.

Pask (1976) takes a similar methodological approach to the study of individual differences in cognitive style: similar in the sense that he uses a single test designed specifically to discriminate between two styles. The basis of this research is different from the kind of experimental studies done by Witkin however as it began with an exploratory approach (Pask and Scott, 1972). Students were put in a free-learning situation where they were asked to learn a body of fictitious subject-matter by turning cards, asking questions and making notes. Cards were arranged according to different classes of information about the subject matter, and students were asked to say at each point why they chose each particular type of information. The open-ended nature of this task meant that the students were not constrained.

* The 'passive spectator approach' was first reported in concept attainment tasks by Heidbreder 1924. This is the only evidence for this approach reported in Woodworth (1938) and in Woodworth and Schlosberg (1954), the revised edition.
in their choice of strategy by the format of the experiment. It was logically possible for a wide variety of different strategies to emerge. On the other hand, the task was sufficiently structured to provide a way of externalising the learning process and thereby provide a way of formalising it.

In fact there emerged from this study two distinct and well-defined strategies of approach to the task, characterised by Pask as 'holist' and 'serialist'. Holists form complex hypotheses about the subject matter and remember and recapitulate it as a whole, whereas serialists form simple hypotheses and learn and recapitulate subject matter in a step by step manner. The same dichotomy can also be defined through a 'teachback' exercise where the students are required to recount what they have learned as though they are teaching it. Here, serialists tend to preserve the order of presentation and use less strictly redundant information (redundant in relation to the teaching or learning goal defined). Holists make major changes in the order of presentation and make more inferential and hypothetical statements in the course of their account. The significance of this kind of dichotomy for practical education is demonstrated by Pask's study of what happens when students are matched or mismatched to a holist or serialist teaching strategy embodied in a programmed learning sequence. Matched students of both types did substantially better on recall tests than mismatched students.

The holist/serialist dichotomy, originally identified in the free learning task, is seen by Pask as an extreme manifestation of the basic processes involved in learning. These are specific strategies which are only elicited in a well-defined interaction between student and subject matter - a "strict conversation" - such as the original task described above. It is well-defined in the sense that the entire subject matter is known (because it is fictitious) and because strict understanding is required i.e. the student must perform an error-free test. Under these conditions a student becomes
entrenched in one strategy or the other, thus providing the mutually exclusive distinction. In normal classroom situations the interaction between student and subject matter is far less well-defined. The requirement for strict understanding is relaxed and students are likely to exhibit biases towards one or other strategy, rather than adherence to them. Thus "some students are disposed to act 'like holists' (comprehension learners) and others 'like serialists' (operation learners) with more or less success". (Pask 1976). The major distinguishing characteristics of comprehension and operation learners are that the former employ description building operations ("pick up an overall picture of the subject matter", "describe the relation between topics") whereas the latter rely on procedure building ("sparse mental picture of material", "assimilates procedures and builds concepts for isolated topics").

Pask's work is interesting for the practising educator because it makes an attempt to operationally define the procedures involved in learning and by doing so enables the identification of characteristic approaches to dealing with subject matter. The fact that his work is based on original studies of what students actually do when they learn, is a particularly important contribution because it demonstrates that even quite complex learning situations are tractable. They are still 'laboratory experiments' in the sense that they are not classroom-based, but they are nevertheless much closer to classroom activities than the origins of most research in this field. This attempt to link the structure of subject matter to individual differences via the actual cognitive activities involved in learning is perhaps one of the most important recent developments in the study of learning.

A further study which uses a test designed to discriminate between different learning strategies is described by Bruner, Goodnow and Austin in 'A Study of Thinking' (1956). Bruner here investigates the particular type of learning strategy involved in concept attainment. The study is based on the theoretical assumption that students adopt a hypothesis testing approach in their selection
of instances of the concept in order to discover the concept itself. The main concern of the study is to show that a strategy that theoretically places less strain on memory, is shown to be more efficient when a greater cognitive strain is introduced (such as requiring subjects to work in their heads, instead of using cards). The study is therefore concerned with general conclusions about strategies of thinking used in various cognitive tests, but in the course of the experiments, a number of individual differences were identified. In selection tasks (where students select cards and are told whether they are instances of the concept or not) students adopted either "scanning" or "focussing" strategies. In reception tasks (where they are presented with cards and told whether they are instances of the concept or not) students adopted "wholist" strategies (focussing on all the features of the first positive instance) or "partist" strategies (focussing on some of the features of the first instance. Since concept attainment, particularly of the type where students have to adopt reception strategies, is an important part of higher education, it is possible that this study could contribute to a study of the strategies students adopt in real learning situations. The study will be discussed in detail in Chapter 4.

A different kind of theoretical basis for the study of individual differences was used by Thorsland and Novak (1974). Students' accounts of problem-solving, based on four physics problems, were analysed according to their bias towards an intuitive or analytic approach. This particular dichotomy was used by Bruner (1960) to characterise the difference between an approach that used "an implicit feel for the subject matter with little or no conscious awareness of the steps used in arriving at an answer" and one that used "a step by step analysis of the problem, very explicit in nature". The dichotomy has a theoretical basis in Ausubel's subsumption theory, which predicts that intuitive problem solvers would utilise high level subsumers whereas analytic solvers would utilise mainly subordinate concepts, relating
The main purpose of this study was to relate students' bias towards either dimension to their learning efficiency and performance on standard tests. In addition, in using four independent judges to rate students' accounts of their approach, Thorsland and Novak claim to have demonstrated that reliable, characteristic individual differences could be identified. The two types of approach are seen as 'dimensions' of problem-solving style, however, and individuals may use either, both or neither. This result could be expected since judges were asked to rate students independently on each dimension according to Bruner's definitions. The claim rests therefore on the amount of agreement between the judges, on the basis of the definitions offered as discriminators.

The statistical evidence for individual differences along intuitive and analytic dimensions is impressive in this study. But the relationship of the findings to implications for instruction is dubious, as the exact nature of the two approaches is not clear. They are said to derive from learning theory, but the empirical evidence for them is quite separately defined. The study is therefore inconclusive in its implications for the existence of individual differences in problem-solving style. This point is discussed further in section 4.3.2.

The studies covered so far in this section have looked at individual differences in various cognitive activities by deriving, theoretically or empirically, a supposed difference, and then using a specially designed test to differentiate between individuals. An alternative approach is to put individuals into a simulated problem-solving or learning situation, and then study what they do with a view to identifying differences. Examples of this approach are studies of problem-solving such as Durkin (1937), Bloom and

Students were asked to think aloud as they solved a problem, and in some cases to give a supplementary account of their approach retrospectively. The difficulty with this method is that because the analysis is done solely in terms of the protocols, without any theoretical basis, the range of possible outcomes is extremely wide. There are many levels on which problem-solving activity can be described and none of the characteristics identified in the five studies relate to each other. A further problem is that the work has no clear orientation towards implications for teaching methods, except that Cowan suggests that teachers might adapt their style if they are aware of differences in the students' approaches.

A study of student learning that employs the same basic approach, but more successfully has been reported by Marton (1976). Here the identification of individual differences is based on protocols of students' recall of a text they have read. The analysis produced categories of intentional content in the students' summaries of the text, and categories of 'levels of processing' in their accounts of how they learned it. The levels of processing are related to the focus of attention of the students: 'deep level processing' occurs when the student considers what the text is about, i.e. 'the signified'; surface level processing' occurs when the student concentrates on the text itself, i.e. 'the sign'. By relating these categories from students' introspective accounts of their approach, to the categories of learning outcomes, obtained from their summaries of the text, Marton is able to show that levels of processing correlate with levels of outcome, i.e. deep level processing produces a deeper level of understanding than surface level processing, which simply allows the student to reproduce portions of the text. Marton concludes that "research should be directed towards studying what is learned in relation to various concrete contents and towards investigating what conceptual prerequisites the understanding of these contents demands". (1976)
The importance of this study lies in its novel approach to the study of learning. Students are engaged in learning activities that closely approximate to the kind of learning they are expected to do as part of their normal courses. It is therefore likely to produce results which have immediate relevance for practising educators. Secondly, the analysis of learning outcomes is done in a sufficiently open-ended way to allow a 'realistic' appraisal of what the students learned. There is no discriminatory test, instead students are free to construct their own summaries of what they believed the text was about. By doing this, the researchers do not pre-judge the nature of the learning, but rather discover it from their analysis of the protocols. Perhaps the most interesting part of this study, however, is the method used for gaining access to the students' learning processes, i.e. the introspective method. This approach has been strangely neglected by researchers in learning. Indeed, as Marton points out, it has been out of favour since the early part of the twentieth century as psychologists focused more on the behavioural aspects of learning.

In addition to the students' introspective accounts of their learning activity in this particular study, Marton also interviewed them about their work in general, and found that two fundamentally different attitudes emerged. One group "seemed to experience knowledge as a part of themselves, or as a change in their way of conceptualizing certain phenomena in the world around them". For the other group, "knowledge was experienced as something external, something that existed independent of the personality". He concludes that there are two quite different conceptions of learning: "learning as being something you do and learning as being something that happens to you".

Several studies discussed in this section have shown that individual differences in cognitive style can be demonstrated. The method of demonstration has varied from using two different tests, to using one discriminatory test,
to using one test which retroactively discriminates. It is difficult to summarise the implications of these various approaches, however, as they yield widely differing types of individual difference. Perhaps one of the most difficult questions to answer is: to what extent is the individual entrenched in any of these characteristics? Are they inherent, unaltering characteristic styles, or are they dependent on conditions, motivation, maturity etc.? Pask allows versatility; Hudson allows discrepant results; Marton's differential attitudes to learning are reminiscent of the stages of intellectual development documented by Perry (1970), which suggests that the surface-level processors could graduate to being deep-level processors. Given that further research may be needed to determine the exact implications of such research findings for education, what direction should that research take? For the teacher to be able to make use of research on individual differences it is essential that he should know why such differences occur. Thus any study that can produce insights into why the student behaves as he does will be more useful than one that simply states that he will behave either one way or another. Marton's use of the introspective method is an attempt at this, and he has therefore been able to go further in using his results to generate an effective teaching programme (Marton 1976).

Differences between students have been studied in a quite different way in the research on study methods. Here, the aim has been to relate characteristics of study method to academic achievement, and the method of investigation predominantly used has been the questionnaire or inventory. In a survey of recent work, Entwistle identifies several characteristics of study methods that have been considered as important in the various research studies e.g. motivation, organisation, syllabus boundedness/freedom. (Entwistle 1977). The latter has been investigated by Parlett, in a follow-up to Hudson's work, where he showed that syllabus-bound students were more likely to be oriented towards exams, and the demands of the syllabus and course work, whereas
syllabus-free students were more likely to be independent in their study, following personal commitments and interests. Given that differences of this type do exist, between students, there are obvious implications for the practising teacher that he should cater for such differences in his choice of instructional method:

"If the individual differences of students are to be taken seriously, the implications are that alternative approaches to learning should be available" (Entwistle 1976).

What is not clear from these research studies, however, is how far the perceived difference is an inherent difference in learning style, or an inherent difference in response to the system:

"It is not yet clear whether the distinction made between syllabus-bound and syllabus-free is a basic and long-standing psychological difference, or rather a short-term disparity in styles of adaptation to the college environment" (Parlett 1969).

The genesis of particular study habits is yet to be investigated. The relation between study habits and personality has been explored extensively by several researchers (see Entwistle/1977) but the dependence of study habits on contextual factors, such as the nature of the assessment system, the style of teaching and the nature of the subject matter, is still largely an open question. Cluster analysis of inventory scores has shown how some of these factors might be linked with particular study habits (Entwistle 1976), but while this method can provide a preliminary identification of the possible relationships, the further research has not yet been done which will tell us about the nature of those relationships e.g. under what circumstances students adopt particular kinds of study method. As Entwistle has pointed out: "at the moment there seem to be few firm conclusions from this type of research study which could be used by a lecturer in trying to choose an appropriate method of teaching." (Entwistle 1976).

Individual differences in styles of thinking and in styles of study are important considerations for an investigation into how students learn. The
contribution of these various studies to the present research will be outlined in Chapter 2.

1.4. The Teaching-Learning Process

The approaches to learning considered so far have studied (a) the individual, and (b) types of individual. These approaches have both required a certain amount of interpretation of results, according to the closeness of the task to real classroom activities. Research that begins in the classroom, however, has the advantage of having implications that are more immediately relevant to the classroom. Research in the field of educational technology is expressly directed towards the classroom — "it is a rational, problem-solving approach to education, a way of thinking sceptically and systematically about learning and teaching" (Rowntree 1974). Part of the rationale behind this approach comes from the recognition that much educational research has failed to help the practising educator: "it is one of the potentials of educational technology to make educational research more practice-oriented i.e. to test and validate theory and research by applying it to the solution of day to day problems in teaching and learning" (Hirst 1971).

The location of research within the classroom, and the aim of greater relevance, may broadly define the field of educational technology, but within that field there is still a wide range of research strategies. Indeed the same location and aim are shared by research strategies that are not normally classified as educational technology. The work on aptitude treatment interactions, for example, takes the teaching-learning process as its focus, but uses a quite different kind of research methodology. In this section, we consider the approach to the problem of learning via the study of the teaching process itself.
The work on aptitude treatment interactions (ATI) is linked to studies of individual differences inasmuch as it considers the consequences of an interaction between different personal 'aptitudes' and different teaching 'treatments'. The methodology is quite different, however, as it analyses the learning outcomes from alternative teaching methods, and finds a correlation between these and such personological variables as introversion, verbal ability etc. One problem with this approach as Bracht (1970) points out, is that most of the research has not been done with ATI in mind, as the identification of the personological variables was done after the analysis of alternative treatments. The research has not followed the approach suggested by Cronbach and Snow (1969) which identifies all variables in advance of the analysis.

The reason for this repeated post hoc analysis of personological variables can perhaps be found in the history of comparative studies of alternative teaching methods. Comparative studies were seen as a way of choosing between teaching methods on the grounds of effectiveness, or more often, as a way of proving the greater effectiveness of an innovatory teaching method. Typically, two matched groups of students were given different teaching programmes and their learning gains were assessed on the same test, the results of which were statistically analysed. In their summary of this kind of work, Dubin and Taveggia (1968) analysed results from ninety-one comparative studies of college teaching techniques, conducted between 1924 and 1965, and concluded "the data are overwhelming in the direction of no differences among various methods of college instruction". The post hoc identification of personological variables provided a more interesting result than the all-too-common 'no significant difference' in these comparative studies.

One major difficulty with this comparative approach to research in teaching is that the studies are only very loosely related to any theoretical
framework. When a correlation fails, or no significant difference occurs, there is little possibility of a theoretical explanation. Greeno (1972) is an exception to this. He describes an experiment by Mayer which compared two different ways of teaching the binomial formula:

"The Formula Sequence began with a statement of the binomial formula and proceeded through a sequence in which various components of the formula were explained. The Concept Sequence began by introducing the component variables to the subject in relation to general concepts, and then proceeded to show how they are combined in the formula, finally showing the formula at the end."

The two methods produced "about equal overall achievement" on the test given to the two groups of subjects. The aim of the experiment, however, was to give information about differences in the nature of learned structures - "what kind of learning rather than how much". The analysis of results for the different kinds of questions in the test, then enabled him to arrive at an interpretation of different kinds of learning for the two methods.

Because Greeno uses a theoretical framework derived from Ausubel's notion of cognitive structure, he is able to explain differences in the pattern of results obtained in terms of 'internal connectedness' and 'external connectedness'. Subjects who used the Formula Sequence achieved internal connectedness - the components of a structure (namely the binomial formula) are strongly connected to each other; subjects who used the Concept Sequence achieved external connectedness - "components of the structure are strongly connected to other contents of the person's mind". The theoretical framework thus provided a basis for interpreting qualitative differences in learning outcomes in relation to the teaching inputs, even though no quantitative difference existed.

The possibility of an interaction between the teaching method and the nature of the consequent learning clearly has important implications for the design of learning materials, but surprisingly this kind of study has its origins in psychology (e.g. Katona 1940; Szekely 1950) rather than education. This
may be because the approach is based on the kind of theoretical framework which educational technologists, for example, are reluctant to embrace. It is only recently that this kind of interaction has gained importance in educational research, although in a quite different way, as will be discussed later.

The approach of educational technology is to treat the teaching method itself as problematic: using an empirical approach, it is possible to adjust the teaching method to produce improved learning gains. The systematic development of a teaching method was a cycle based on the sequence: define objectives, design method, implement, evaluate, redesign method (McKenzie, Erut & Jones 1970, Rowntree 1974). It is not, therefore, directly related to research in student learning. The design of teaching methods may utilise research results (e.g. Keller 1968, Mager & Clark 1963), but does not specifically produce generalisable research findings, except insofar as the teaching method developed may be transferable to other teaching situations.

With the increase in programmes of educational innovation in recent years, the methodology of evaluation has gained in importance as evaluation itself has been seen as a necessary part of any innovation or development strategy. At the same time, an increasing dissatisfaction with the limitations of comparative studies and aptitude-treatment interaction analysis discussed, for example, by Trent and Cohen (1973) in their review of this type of research, led to new directions in evaluation methodology (Hamilton and Delamont 1974).

The new methodology was characterised by an open-ended, exploratory approach that took the whole teaching-learning process as problematic. Regarded holistically, learning can be seen as part of the context within which it occurs and this relationship between contextual factors and the nature of
student learning has been explored in several studies (e.g. Parlett and King 1971, Dearden and Laurillard 1977, Smith and Pohland 1973). The power of this approach can be illustrated by examples from 'Concentrated Study, a Pedagogic Innovation Observed' (Parlett and King 1971). Using open-ended questionnaires, interviews and observations, it was possible to establish several links between contextual factors, such as organisational aspects of the innovation, and the type of learning achieved by the students. Students felt that "their knowledge was richer, more diversified, more interesting, more interconnected and unified". They attributed this to a number of factors: the opportunity for lab. work; the instructor's digressions to include other parts of physics, and his anecdotes about physicists; and the films, visits, projects and so on." On the other hand students felt uncertain that the course would equip them to pass a conventional exam; the kind of learning they were experiencing enabled them to "get more deeply into physics", to "see how a physicist actually works", but by its very nature, the course did not dwell on the kind of drill and practice with problems that was necessary for the finals. Thus "connecting changes in the learning milieu with intellectual experiences of students is one of the chief concerns for illuminative evaluation" (Parlett and Hamilton 1972).

This approach to the study of student learning gives quite different information from that generated by the research methods described earlier in this section. The value of illuminative evaluation lies in the fact that, unlike other research methods in education, it does not pre-judge the nature of its findings and is therefore not hindered by having to mould the vast complexities of the educational process into a formal research design. Instead the complexity is recognised and a structure is allowed to emerge according to the salient issues in the situation under study. The outcomes from this approach are characterised by the relationship they establish between contextual factors and student learning. The methodology is
sufficiently new for it to be difficult to find any generalisations about the exact nature of this relationship, and this point will be discussed further in later chapters.

1.5. Conclusions

This survey started out with the aim of considering those research studies that could contribute to an investigation of the kind of high-level meaningful learning found in higher education. For the three areas of theoretical approaches to learning, individual differences in learning and the teaching-learning process, I have discussed the relationship between the methodology used and the research outcomes, and their implications for the practising teacher.

Theories of learning and instruction have produced some valuable ways of looking at the teaching-learning process, but they have not embraced the complexity of the reality. They have told us how students might learn, but they have not investigated how they actually learn. For the immediate purposes of the present study, therefore, they do not provide a starting point for the research.

Some of the studies of individual differences, however, have taken the approach of studying student learning in an exploratory way. The consequence of starting this way is that instead of positing features of learning and studying those, they derive features of learning from the practice of it. These studies are more likely to contribute to an understanding of the teaching-learning process that will be of practical use because they have a better chance of focusing on the most important features of the reality.

Finally, the study of instructional methods has used a variety of methodological
approaches. The traditional approaches of comparative studies and aptitude-treatment interactions have not provided a fruitful line of research. Studies of particular teaching methods are useful but do not contribute to an understanding of student learning since they assume the understanding provided by their theoretical bases. The newer exploratory approach to the study of teaching methods, may however be capable of providing a full description of the phenomena which the theories have to explain, and these could therefore contribute to a better theoretical understanding of student learning.

In Chapter 2, I will describe how these various studies have formed the basis of the present research study.
2.1. Introduction

From the review of the state of the art in research on student learning, it can be seen that a coherent understanding of the learning process in all its ramifications is not yet available to us. Researchers have tackled the problem in a variety of different ways which inevitably results in a diverse collection of models of different aspects of learning which cannot easily be subsumed under a single theoretical framework. This would not matter greatly to the practising educator if the individual models were themselves couched in terms that made them usable and moreover, since they tackle different aspects of learning, were usable in conjunction with each other. The teacher's perspective is a holistic one; he will wish to make use of research in areas as diverse as those researched by Gagné, Pask and Parlett, and yet it is hard to see how he can easily bring all these together in his teaching programme, as Atkin (1967) has pointed out:

"In the field of educational research and development, we need a swing of this micro-macro pendulum - a swing toward the macro. We seem now to be labouring with a type of reductionism in which it is very difficult to put the various pieces together".

The problem remains that the educational researcher must attempt to extract what he can from current research to provide a clear and coherent understanding of the learning process that can be exploited by teachers and implemented within their teaching programmes. One strategy the educational researcher might adopt is to incorporate some of the ideas, the concepts and the results from existing research, to build on these where appropriate, but at the same time, to adopt a different research methodology from that used most widely in educational research. Whereas a wide diversity of types of model of the learning process has been generated by research strategies which focus on particular aspects of learning, an alternative methodology could attempt to
parallel the holistic perspective of the teacher by looking at the total learning process, thus taking a holistic approach to the problem of learning. It is the purpose of this chapter to argue for this alternative approach, and to consider some of the methodological issues it raises.

2.2. The nature of the research problem

How can the problem of learning be turned into a researchable problem? The formulation of the problem will itself determine the nature of the outcome to some extent, and it is therefore important to consider the kind of outcome that it is reasonable to aim for - what kind of description is appropriate and useful as an outcome of an investigation of learning?

The paradigms of research methodology are in the process of undergoing considerable rethinking within the social sciences. In his address to the American Psychological Association in 1974, Cronbach considered the past thirty years of nomothetic research in psychology:

"Model building and hypothesis testing became the ruling ideal, and research problems were increasingly chosen to fit that mode. Taking stock today, I think most of us judge theoretical progress to have been disappointing".

In reviewing, in particular, the work on Aptitude-Treatment Interactions, Cronbach concluded that the source of the failure of the "ruling ideal" lay in the nature of the complexity of human behaviour. It is not realistic to expect the reduction of behaviour to laws because it is not possible to isolate individual components of behaviour in order to establish the relation between them: "Once we attend to interactions we enter a hall of mirrors that extends to infinity". (Cronbach 1975). The solution that Cronbach proposes is that researchers should concentrate on "interpretation in context" as opposed to generalisation. The significant/non-significant
dichotomy is not sufficiently fruitful in the production of worthwhile research results because it ignores the wealth of descriptive data available outside the confines of the statistical method:

"Instead of making generalisation the ruling consideration in our research, I suggest that we reverse our priorities. An observer collecting data in one particular situation is in a position to appraise a practice or proposition in that setting. Observing effects in context. In trying to describe and account for what happened, he will give attention to whatever variables were controlled, but he will give equally careful attention to uncontrolled conditions."  (Cronbach 1975)

The conclusion Cronbach has come to, therefore, is that the kind of data that should be the focus of the educational psychologists' research, is too rich and too complex to be encapsulated within the kind of formal research design that has been prevalent. He does allow that a formal research design is a legitimate procedure, but he warns that it must be supplemented by descriptive data about the context within which it occurred for the interpretation of the data to be valid. He sees the outcome of such research not as being generalisations which build an overarching theoretical framework; instead, the generalisations will be built slowly, through a series of studies each interpreted within its own context, each being explored for any local factors that may have caused a departure from the "mod 1 effect". It is a philosophy that legitimises a whole new body of data as being capable of contributing to the final outcome, and in doing so creates a quite different expectation of what the nature of the outcome can be.

In a different field of educational research, a similar point is made by Hamilton (1977) who considers the historical development of curriculum evaluation. This again began with the early adoption of the scientific paradigm, and again it proved to be inappropriate:

"Given the assumption of goal consensus, the implementation of an evaluation rationale hinges upon the comparison of various means to achieve such ends. From John Stuart Mill and John Dewey, to Ralph Tyler and Michael Scriven, the possibility of realising a theory of evaluation rested upon this assumption."  (Hamilton 1977)
But why the assumption of goal consensus? As Hamilton points out, the evaluation strategies adopted within this paradigm, "presume that values which are shared are more significant than discrepant values. There is no logical reason why this should be the case." Once multiple value positions are allowed as legitimate the scientific paradigm can no longer function as nothing is 'given'; objectives, theories, methods of measurement are all problematic.

This analysis of curriculum evaluation focuses on a quite different aspect of educational research than does Cronbach's analysis. Whereas Cronbach demonstrates that the complexity of educational phenomena requires a holistic approach to research, Hamilton demonstrates that the existence of different values among the participants in education necessitates a pluralistic approach to evaluation. But why is this pluralism of values permissible? It is precisely because of the complexity of educational phenomena. To take an example, it would be possible for an innovatory programme to be highly valued by teachers because it trains students to perform certain procedures efficiently and yet the students themselves may dismiss it as being uninteresting and irrelevant. The same programme, the same student activities, the same student performances can be judged differentially because all these apparently objective factual data are interpreted by the participants in the light of such highly subjective variables as motivation, individual learning strategies, and personal preferences, and within the context of the total teaching and learning milieu. It is this complexity that makes it counterproductive to isolate parts of the system for investigation (c.f. Cronbach) and at the same time results in the production of legitimate alternative interpretations of it. (c.f. Hamilton). Thus Cronbach's exhortation to a holistic approach derives from the same source as Hamilton's pluralism.

In considering the nature of the outcome of an investigation on learning, it
is clear, therefore, that it would be unwise to aim for a nomothetic account; that it would be advisable to follow Myron Atkin's suggestion:

"I am suggesting a direct onslaught on the total educational picture, as a substitute for the fragmentary approach that presently characterises most educational research." (Atkin 1967)

The outcome of this approach is not explicitly predicted by these writers, but it will certainly be different in kind from that produced by earlier methodologies.

While the above critiques derive from a recognition of the importance of the interaction between variables, and of the recondite nature of some of those variables, there is a further problem that will affect the nature of a feasible outcome for this kind of research. It is the problem of the nature of the relationship between the variables: to what extent can it be seen as a causal relationship? The scientific paradigm has provided more than a methodology for social science; it has also provided a set of assumptions about the nature of the reality it attempts to describe. But the isolation and elimination of variables may not always be possible within the context of human behaviour. There has been surprisingly little discussion of this problem as an aspect of educational research, although Entwistle has referred to it briefly:

"Reversals in the direction of causality are easy enough to imagine in higher education. Does motivation cause high achievement or the reverse? In practice presumably it acts in both directions ...... statistical analysis of psychometric data does not allow us to explain such complex interactions between variables within a simple cause and effect model of human behaviour." (Entwistle 1974).

The problem of causality derives from the fact that human behaviour is highly adaptive and self-regulating. A simple cause and effect model is unlikely to be an adequate description as there will be a mutual interaction between many of the variables identified, so that a different type of model will be necessary.
The conclusion, from this preliminary analysis of what the outcome of an investigation of learning might be, amounts to a description of what the outcome should not be. It should not be an analysis of the relationship between a previously defined set of variables (Cronbach, Hamilton), and it should not be a simple cause and effect model. The style of the methodology has been outlined, but the kind of description it is legitimate to aim for has not been defined. It is the aim of the next section to establish the formulation of a suitable research problem, given the kinds of constraints outlined here.

2.3. The formulation of the research problem.

There are two aspects to the formulation of a research problem: the content, and the methodology, which will determine the form. As a starting point, it is important to consider (a) the most promising avenues of the current research on learning, and (b) the methodological approaches that are available and are suitable given the nature of the content. The two together will contribute to the formulation of a research problem consistent with both.

2.3.1. The outcomes from current research on learning.

In Chapter 1, the current state of research on learning was summarised as falling into three major types: one that attempts to establish a psychological model of the process of learning; one that studies individual characteristics of learning; and one that looks at learning in the context of teaching. The first approach is highly theoretical: an attempt to establish 'the way things can be', whereas the purpose of the present study is to attempt to establish 'the way things are'. The methods adopted by researchers under the latter two descriptions are more compatible with this aim, and the outcomes of their research therefore provide a good starting
Considering representatives of the latter two approaches: the approach of Pask and Marton is to study the cognitive aspects of what happens when a student undertakes a learning task. Parlett and Hamilton, on the other hand, study the contextual aspects of learning and the kind of influence they have on students. The methodologies are different, and the researchers are studying different aspects of student learning. But both are important to the teacher who must take into account both the content and the context of the teaching-learning process if he is to operate successfully within it. Considering now the outcomes from these research areas, what implications do they have for future research?

Pask has identified two "styles" of learning which predispose the learner to adopt two different types of "strategy". This work provides a good basis for further exploration for three reasons: (a) he began with an open-ended free learning task which permitted the discovery of learning variables, (b) the learning task used was sufficiently complex to be capable of providing insights into high-level learning, and (c) in spite of an open-ended approach, the results were well-defined and highly differentiated. It is not clear, however, whether these identified characteristic styles are consistent for each individual. Pask certainly suggests that the holist is always a holist, and indeed the distinction is so marked that it seems to be capable of coinciding with subject boundaries. The styles of comprehension and operation learning are similarly differentiated, and yet the definitions of them suggest that both are necessary in many areas of high-level learning. Pask's work is at an early stage of development, but even at this stage it is legitimate to ask whether the identified characteristics can discriminate between high-level learners, and do indeed indicate valid individual differences. The consistency and high discriminability of his results cannot
be ignored, but it is difficult to interpret them in terms of their implications for students' performance in normal learning activities.

To what extent is the student's learning style dependent on the conditions of the test, his perception of the task, the nature of the task and the circumstances surrounding it? To what extent does his performance on the test transfer to other types of learning situation?

In contrast to Pask, Marton has studied students' perception of a learning task and has related it to their performance on the task. The value of Marton's work as a basis for further research lies in the fact that (a) he uses a learning task of exactly the same type as the students' normal work, and (b) he exploits the students' ability to introspect on what they were doing in the task. Once again the approach was open-ended, and did not presuppose that any particular types of learning variables would be found. As a result, Marton was able to establish an unusual type of individual difference, namely a difference in level: some students used deep-level processing, and some used surface-level processing. The emergence of these descriptions came not from the outcome of tests, nor from an analysis of the student's approach such as that used by Pask. It is Marton's adoption of the introspective technique that produces the differentiation between levels of processing. The fact that he was able to support the dichotomy with evidence from test results lends additional support to the interpretative analysis of students' introspections.*

The interpretative analysis Marton used, however, provides indirect evidence of their perception of the task rather than direct evidence. By asking students to describe their approach he was able to elicit what they were doing, and from the analysis of these protocols, he deduced that there were

* This study is discussed in more detail in Chapter 4.
two different ways of perceiving the task: attending to the 'sign' and to the 'signified'. He did not ask them directly about their perception of the task, or why they approached it in the way they did. It is still possible, therefore, to ask the same questions as of Pask's study: to what extent do these differences transfer to other learning situations, and to what extent do these approaches depend upon the students' perceptions of the nature of the task?

Both Pask and Marton have identified important apparent differences in students' approach to learning. Both have begun with an exploratory approach which has produced interesting insights into the cognitive aspects of the learning process, and both have been able to support their interpretative findings with well-defined test results. They have attempted to explore learning situations which closely mirror those found in the students' normal experience, but the environmental conditions are not the same. Whether the conditions of normal learning situations are importantly different, and whether they have a significant effect on a student's performance, will affect the transferability of these results.

2.3.2. The outcomes from evaluation of learning

The importance of the effect of the context of the learning milieu upon students' performance is being increasingly recognised in the separate research tradition of educational evaluation. In their seminal paper, Parlett and Hamilton (1972) argue that "innovatory programmes, even for research purposes, cannot sensibly be separated from the learning milieux of which they become part". Educational evaluation methodology had hitherto been developed within the same scientific tradition as educational research, but Parlett and Hamilton articulated some of the reasons for the growing dissatisfaction with traditional evaluation models and sought precedents for
alternative models within such disciplines as social psychology, sociology and social anthropology. Some of these are gathered together in 'Beyond the Numbers Game', (ed. Hamilton et al, 1977) which provides a useful document of the change from traditional to alternative methods of evaluation. The new direction is methodology was a response to a need for greater relevance of research results, and inevitably the new methods spawned different types of results. The need for greater relevance meant that the approach was now 'holistic', taking into account information, and making use of sources that had formerly been excluded. The outcomes from this type of approach exposed the paucity of those research models that concentrated on measurable, pre-ordained variables and evaluated innovatory programmes on the basis of content alone.

"Students do not respond merely to presented content and to tasks assigned. Rather, they adapt to and work within the learning milieu taken as an inter-related whole."

(Parlett & Hamilton 1972)

To take some examples:

".... teaching and learning in a particular setting are profoundly influenced by the type of assessment procedures in use; by constraints of scheduling; by the size and diversity of classes; by the availability of teaching assistants, library, computing, and copying facilities."

(Parlett & Hamilton 1972)

Once the possibility of the relevance of contextual phenomena is recognised, and the methodological techniques used are designed to tap these, examples of the significant effect of the context on student learning are numerous. Studies which have adopted this principle produce results such as

(1) students' perceptions of examinations affected their attitudes and the ways they revised (Müller & Parlett 1974); (2) a sense of group identity affected how much students learned through discussion (Parlett & King 1971); (3) students work according to the 'hidden curriculum' embodied in the grading system (Snyder 1971); (4) teachers' attitudes to innovatory material affected the amount of work students were prepared to put into it (Laurillard 1978). Results of studies such as these are, by their nature,
context-dependent, and the precise effects may differ from place to place. But the conclusion that is generalisable from all such studies is that the students' perception of the teaching and learning milieu has an effect on what they do when they set out to learn.

Evaluation studies set out to describe the implementation of an innovation: to show how participants respond to it, how it operates, the changes it precipitates, the factors that contribute to its success and failure, the performance of students within it. These studies have identified a number of important contextual factors, but have not related these explicitly to what students learn, because this requires something more than an evaluation study. They do, nonetheless, discuss the relationship between contextual factors and some aspects of how students learn. It is this study of the relationships within teaching and learning that makes the methodology a valuable one to follow.

This alternative methodology has often been referred to as a "new paradigm", but this is a misnomer. 'Paradigms', in Kuhn's sense are "more successful than their competitors in solving a few problems that the group of practitioners has come to recognise as acute" (Kuhn 1962). The paradigm is based on a model piece of research, progressively articulated by further research within that paradigm. The new methodology has not yet achieved that status because insufficient work has been done for it to be widely acclaimed as a notable success. It has acquired the status of a putative paradigm largely because of the failure of the traditional paradigm: it can hardly fail to be more successful.

Criticisms of the new methodology have focussed particularly on its lack of rigour. While expressing considerable dissatisfaction with the traditional methods of educational research, Entwistle (1974) nevertheless warns against
an over-reaction that abandons all attempt at objective evidence, and argues instead for a variety of approaches to the study of education which will include both subjective data, e.g. from interviews, and objective data e.g. from tests. The combination of the two may overcome the inherent uncertainties of each type of data.

Parsons (1976) provides a critique of "The New Evaluation" although his arguments are largely ad hominem. His criticisms are that the original paper (Parlett & Hamilton 1972) failed to integrate the methodology with its historical precedents in sociology and social anthropology, that it thereby paid too little attention to methodological rigour, that it avoided any assumption of a theoretical model, and that the priority of being responsive to decision-makers made it essentially conservative of the status quo.

It is perhaps unfortunate that a seminal paper has its intentions defined by its recipients, but in any case the first two points, which are not criticisms of the methodology, are answered in the collection 'Beyond the Numbers Game'. (Hamilton et al 1977). That the methodology embraces no particular theoretical model is a consequence of its exploratory nature. It is characteristic of it that it generates rather than confirms theory, and here it clearly has its roots in sociological work such as Becker (1968) and Glaser and Strauss (1968). But to suggest that the authors intend "to enter the field in ignorance of the accumulated wealth of conceptual and theoretical schemes available" is to make an unjustified inference from the fact that they do not discuss theoretical models.

The most penetrating criticism is the final one, as the potentially conservative orientation that results from focussing on the requirements of decision-makers conflicts with the aim to discover unintended outcomes. Similarly, Stenhouse (1975) warns that "The task of briefing decision-makers in language they readily understand can too easily lead to the casual.
importation of unexamined assumptions and criteria. Using the new methodology for research rather than evaluation avoids this particular problem as there is no client. There is an audience, and clearly any research methodology must take the requirements of its audience into account. But the audience does not have to define the nature of the outcomes. The requirement is that the research results should be usable by that audience, and this is one of the stated aims of my research.

The value of the new methodology for this research study lies partly in its implicit theoretical content: that student learning must be seen in the context of the teaching-learning situation, and partly in the exploratory, theory-generating nature of its methods. It is not yet a well-defined methodological package, however, and that is why a more detailed discussion of methodological principles is necessary in section 2.4.

Taking the two current, but widely differing areas of educational research described here, it is clear that important advances are being made in what might be characterised as cognitive and contextual aspects of learning. The outcomes of research in both areas have important implications for educational practice. If students have significantly different characteristic approaches to learning, then some flexibility should be allowed for in the design of educational materials. Similarly, if conditions in the learning milieu can significantly affect a student's approach to learning then these should be considered in the design of educational methods. What is lacking, however, is an account of the relationship between these two aspects of learning. How do contextual and cognitive factors interact, and what kind of effect do they both have upon what the student learns? If there is any validity in the outcomes of the two different research approaches, then the teacher must know how to utilise both together. They cannot be assumed to operate independently of each other. Indeed the whole point of Parlett and
hamilton's approach is to underline the fact that students respond to both content and context.

The research problem as formulated so far, therefore, is an attempt to link two of the most promising aspects of current research on learning: to explore the relationship between the students' response to the content of their work and to the context within which they work. With reference to the methodological constraints outlined in section 2.2, this formulation as yet avoids any presupposition of either a causal relationship between variables, or the nature of the variables that are relevant. The problem requires the kind of exploratory approach that is consistent with the new directions in educational research methodology, but the area is not completely uncharted. The problem has its roots in current research outcomes, and these provide a basis for the beginning of the exploration. The conduct of the exploration requires a coherent methodological approach, which will be discussed in the next section.

2.4. Philosophy of methodological approach

This section will outline the basic methodological principles for this research study, and relate these to the research techniques adopted. The details of these techniques will be discussed in Chapter 3. The aim of this section is to provide the theoretical justification for the overall methodological approach. Each subsection discusses one of the principles that characterises this particular approach.

2.4.1. Explore the parameters of learning

It is appropriate to begin with a more general reformulation of the research problem. The discussion of current research on learning led to a fairly
precise formulation in section 2.3.2. that attempts to relate current research findings on individual differences to the work on the effect of the context on learning. This gives a reasonably well-defined focus to the study, but it is also appropriate to see it in a broader perspective.

The study of learning has been approached in many different ways, some of which have been discussed in Chapter 1. These various studies have contributed valuable ideas and concepts about the nature of learning, but the wide range of approaches leaves them more or less unconnected. A more exploratory approach would attempt to identify the nature of some of the parameters that affect learning, and where appropriate to utilise previously defined concepts. The two types of parameter that have been derived from the literature as being worthy of special attention are 'individual differences in learning style' and 'students' responses to the context of learning'.

The point of adopting an exploratory approach is to avoid confining the study to these two, and along with the current trends in educational research methodology, to avoid a piecemeal approach, and to allow for the emergence of different types of parameter, or different parameters with those types.

But what does 'exploration' mean? It cannot mean the pure Baconian collection of factual observations; it may be open-ended, but it is not empty-minded. As Popper and Lakatos have pointed out "There is no natural demarcation between observational and theoretical propositions" (Lakatos 1970); observations are dependent upon their theoretical context. As we have seen in Chapter 1, different theoretical contexts, whether articulated or not, set up different problems, employ different methods, and hence derive different observational outcomes. But if an exploratory approach is necessarily couched within a theoretical framework, what does it gain over these other approaches?
Existing research results have investigated a variety of different aspects of learning such as structure of material, personality characteristics, teaching method etc. The context of the learning milieu has recently emerged as an important aspect of learning, but this has not been fully investigated. The contribution that an exploratory approach can make, therefore, and that marks it out from other theoretical approaches, is to recognise the multiplicity of possible sources of influence on learning. The relationships between the established parameters of learning are still vague. The wide range of sources of influence implicit in a recognition of the importance of the context of learning adds further uncertainty.

The theoretical stance appropriate to an exploratory approach, then, is to admit the existence of this wide variety of influences on learning, to investigate some of them further, and to discover the nature of the interaction between them. One implication of this is that the methods adopted to investigate the different aspects of learning will differ and will be drawn from existing studies. Another implication derives from the need to reduce the ambitious nature of the task as defined. In 23.1 a subset of some of the most interesting kinds of current research were discussed in the formulation of a reasonably well-defined research problem. This limits the range of the study but does not affect its exploratory nature.

This exploratory approach does have a theoretical framework: it amounts to postulating (a) the existence of a variety of sources of influence on learning, and (b) that there is some relationship between them. The generation of theory in the form of the nature of this relationship and the nature of those sources previously uninvestigated will come from the data itself. The process of generating theory from data is the subject of the next section.
2.4.2. The theory can be grounded in reality

One of the overall aims of this study is to ensure that the research outcomes will be relevant to educational practice. The aim of the exploratory approach outlined above is to derive descriptions of some of the parameters of learning and the relations between them. For both these reasons it is essential that the study itself should focus on real learning situations.

Most studies of aspects of learning have depended upon experimental situations, some of which (e.g. Pask and Marton) have been close approximations to the normal learning experiences encountered by students. The only studies to have focussed particularly on real learning situations are those in the field of educational evaluation. It is inevitable that educational evaluation should be grounded in reality because its aim is to produce information about a particular programme that will be relevant and useful to its participants. In doing so, however, its proponents have produced some interesting insights into aspects of learning that have not been investigated properly before, such as those described in section 2.3.2.

It is therefore appropriate for research on learning to borrow the methodology of educational evaluation, and thereby expect to produce research results that are capable to being relevant and useful to the participants in learning.

The methodological approach recently adopted in educational evaluation has itself been borrowed from the disciplines of sociology, anthropology and social psychology. The methodological changes were born of dissatisfaction with traditional educational evaluation and have been developed in a wide range of evaluation studies by Becker (1958), Hamilton (1973), Smith and Pohland (1974), Parlett (1975), Stake (1975), MacDonald (1977) and many others. One of the major precepts on which the new methodology was founded,
was the importance of avoiding the pre-specification of research strategies. The traditional approach had led to parsimonious, unusable results that totally failed to reflect the richness of the educational programmes being investigated. The critique of this approach, led by Atkin and Cronbach called for a radical change, an open-ended, holistic approach that would be capable of reflecting the reality under study. It was indeed a radical change, but the necessary methodology already existed. The disciplines of sociology, anthropology and social psychology had already developed methodological procedures that were capable of dealing with a complex reality without forcing it into the procrustean bed of a pre-specified research design.

In learning research, as in educational evaluation, there is criticism of irrelevant and unusable results. The need for an exploratory approach has been discussed in section 2.4.1; the methodology adopted by recent evaluation studies provides the means. The methodological procedures developed in sociology and related disciplines specify the practice of the exploratory approach. The details of techniques such as participant observation, grounded theory, and the constant comparative method for data analysis, will be discussed in Chapter 3. The argument here is that learning research needs to be grounded in reality, and must therefore use the methodological techniques currently being developed to investigate the learning process as it occurs in reality. At least part of this study must focus on the student's normal work, his response to it, and his methods of dealing with it.

2.4.3. Case studies can produce generalisations

Given that the aim of the research study so far, is to explore the parameters that affect learning, by studying students in relation to their normal work, this puts some further constraints on the nature of the study. It cannot rely on a theory-based experimental approach, since there is no established
theory. And it cannot be survey research, since this requires that the researcher knows in advance the characteristics and properties he wants to study. In fact, some of the procedures of survey research could unnecessarily delimit the available sources of information. Hamilton (1976) argues that in survey research "no distinction is made between a person's (overt) behaviour and his or her (covert) intentions". As a result of giving priority to observable data categories, "survey analysis inevitably reduces non-observable phenomena ..... to a lower level of significance" (Hamilton 1976). But it is precisely the 'intentions' and the 'non-observable phenomena' that are important in this study. An exploratory study such as the one planned cannot therefore use these standard methods of educational enquiry. Hamilton argues for the adoption of case study research as being more compatible with current educational research methods. There are three main reasons: (i) educational phenomena are social and artefactual, dependent upon the context within which they occur, and identifiable variables are mutually interactive rather than obeying a simple cause-effect model (c.f. section 2.2.); (ii) it is more fruitful to give more credence to perceptual and subjective information than to objective, observable data; (iii) educational phenomena are not amenable to generalisations; these should be substituted by 'interpretations in context', thus acknowledging the dependence of the phenomena on the context within which they occur.

The characteristics of case study methodology are important for an exploratory study because they widen the legitimate sources of information, and allow a more intensive study of individual cases. When the variables themselves are yet to be discovered, the use of perceptual and subjective data can be an aid to exploration. Examples of this type of study can be found in Perry (1970), and Bliss and Ogborn (1977).* Perry was exploring undergraduates' intellectual development; Bliss and Ogborn were exploring students' reactions.

* Also Pask and Marton, as previously mentioned.
to their science courses. Both studies were exploratory in the sense that
the parameters themselves were not defined but were discovered in the
course of the study from the analysis of data. Similarly, both studies
made extensive (almost exclusive) use of students' introspections, and it
was the analysis of this perceptual and subjective data that generated the
relevant parameters in each case.

In a research area such as student learning, where, as I have argued, only
some of the relevant parameters have been investigated, this kind of approach
can be highly productive. There can be few better sources for the generation
of new parameters than the practitioners of learning themselves.

Can such a study produce generalisable results? Entwistle/(1977) suggest
that Perry has "weakened his thesis by an exclusive reliance on impression­
istic interview data". Certainly the validity of students' perceptions of
learning as an indicator of the processes of learning is questionable since
students may be mistaken in their perceptions. To some extent their perceptions
can be checked independently, as in Marton's and Pask's work. If this is not
possible, the interpretation of results must be treated with care. But
impressionistic data should not be dismissed; the ways students perceive
their learning experiences are themselves important factors in the study of
learning and provide valuable insights to the researcher, if treated with
appropriate care. The status of the research results has been described as
'interpretation in context', and applies to the kind of case-study that
examines an individual programme or institution. The kind of case study that
is proposed here is different from this, as it examines individuals within
their own context. Thus the logic of the relation between the nature of the
study and the status of the research outcomes, is slightly different.
'Interpretation in context' is used to underline the dependence of the
phenomena on their context. But if the individual case studies already take
account of this - each one being an interpretation in context - then the results from a number of such case studies will be capable of supporting generalisations about individuals within their context. Because of their genesis, from contextual interpretations, these generalisations will not be so vulnerable to Cronbach's criticisms (section 2.2.) and therefore the study can hope to produce some form of (albeit tentative) generalisation.

2.5. Summary

To summarise the main points of this methodological approach, the aim of the study is

(a) to explore some of the factors that affect student learning, and the nature of the relationship between them,

(b) in particular to explore the relationship between those cognitive and contextual factors that have been identified by current researches,

(c) to make use of students' ability to introspect about their work and their perceptions of it,

(d) in addition to the replication of current research results, to study students in their normal working situations,

(e) to make in-depth studies of individual students and the contexts within which they work in order to support some generalisations about the nature of the relationships between the different factors identified.

The details of the methodological techniques that derive from these points will be discussed within later chapters.
3.1. Introduction

The overall aim of the present research study is to investigate the parameters of student learning. The survey of research literature in Chapter 1 has indicated that there are some research findings on learning, such as identifications of individual difference, that may provide a starting point for the investigation. However, as has been discussed in Chapter 2, there are a number of methodological issues in this kind of research that remain problematic. The research methods and techniques used in this study have been chosen with these problems in mind.

The research methods can be categorised as three different types: replication studies (using the same methods in the same way as the research studies described in the literature), extension studies (using similar methods to those used in other research studies, but applying them to students' normal work, rather than to experimental learning situations) and exploratory studies (mainly in-depth, structured and unstructured interviews about the students' perceptions of their academic work).

The three different types of study were employed at different stages of the research. The five stages are defined chronologically (see Table 3.1).

Thus the research is anchored in the literature by the various replication studies done, but has also been able to explore the contextual influences on the learning situations studied, by means of open-ended interviews, and structured questionnaires.
<table>
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<tr>
<th>TECHNIQUES USED</th>
<th>STAGE A. (FEASIBILITY)</th>
<th>STAGE B (PILOT)</th>
<th>STAGE C. (MAIN STUDY)</th>
<th>STAGE E.</th>
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<td>Interviews (Extension)</td>
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<td>May-July 1977</td>
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<td>Reading Interviews (Extension)</td>
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<td>Open-Ended Interviews (Exploratory)</td>
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<td>Parlett (Replication)</td>
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<td>Pasik (Replication)</td>
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<td>Questionnaire on Spying History Test (Exploratory)</td>
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<td>10</td>
<td>10</td>
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<td>31</td>
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The stages will be described chronologically in terms of the various methods and techniques introduced at each stage.

3.2. Stage A: Feasibility Stage

3.2.1. Aim

The replication studies planned did not present any particular methodological problems, and could be carried out without the need for a feasibility study. The extension part of the study was not so straightforward, however, as it had to be based to a large extent on students' reports of their work. The aim of the feasibility stage was to establish whether students could introspect on their work, and whether this yielded protocols that could be analysed according to existing descriptions of student learning such as those already discussed. The exploratory method used is described below.

3.2.2. Method

Two methods of introspection were used for two different types of learning situation, reading and problem-solving. Five students were studied for one session each, lasting in total 40 - 60 minutes.

For the reading task, the students were asked to read some 3 - 4 pages of a physics textbook and were told they would be asked about how they approached it. They spent 15 - 20 minutes in reading, and were interviewed immediately afterwards for about 5 - 10 minutes. All interviews were recorded and transcribed verbatim. This was similar in style to the technique used by Marton in his studies of reading.

For the problem-solving task the students were asked to work through a problem in the same topic area as the reading task, and to 'talk their way through'
The problem. The problem was stated as follows:

A mass $m$ is whirled at constant speed in a vertical circle at the end of a string of length 1, the other end of which is kept fixed. What is the least angular velocity for the string not to become slack?

This process lasted approximately 15 - 25 minutes and was recorded and later transcribed. The technique was similar to that described by Bloom and Broder, Durkin, Cowan, Krutetski and De Groot. Protocols were to be analysed by looking for some of the characteristics found in these studies, where appropriate.

3.2.3. Results

The reading task was successful, with students giving quite detailed accounts of their approach to the task. However, there was a very striking difference between the approaches described, which corresponded closely to some of Pask's descriptions of 'holist' and 'serialist' learners. Three of the students described a holist approach:

"I go all the way through the section just to get the feel of it." Andrew.

"I don't usually bother to work out detail unless I can't see what it refers to ... If I can't work it out, I just miss it out and go back to it later." Ben.

"I just read right through, and if I don't quite get it, I go back .... It's better to go on to the end, to see what you're aiming for." Geoff.

Two students described a serialist approach:

"I read through very carefully line by line. When I understand it, I go on to the next bit." Derek.

"I try to read through, understanding each step as I go... basically steadily working through." Ken.

There is a contrast between the two sets of quotes here that is shown up in what the student appears to be aiming for, at least initially, with respect to this particular task. The first group aim for an overall picture and will fill in details later, whereas the second group concentrate on the detail right from the start. The study was too small, of course, to support
any conclusions, but did fulfil the aim of demonstrating the feasibility of this kind of introspective account in providing analysable data.

The problem-solving task was not so successful. Students found difficulty in performing, simultaneously, the tasks of problem-solving and introspecting. This was shown up by the fact that either their reporting stopped just as they began to find the solution or the entire protocol was a report on the fact that they could not solve the problem. None of the five was successful at both tasks of solving and reporting.

It is possible that the students were unable to give detailed reports of their solutions because the problem was too simple and admitted only a fairly mechanical type of solution process. Other studies of problem-solving which have used the technique of simultaneous introspection have apparently been successful. However, Durkin (1937) says that the reports done introspectively were more valuable; Bloom and Broder (1950) used problems that were unfamiliar to the students and could not be done mechanically; Cowan (1977) used problems that were typical of those normally done by the students in their course, but were more complex than the type used in the present study, and therefore admitted a wider range of possible solutions. Krutetski (1976) used mathematical problems of the type that admit a mechanical solution process and are therefore difficult to introspect on. To overcome this, he took care to make sure that the students understood that they were required to 'think aloud', not to explain the solution. Secondly, the students were trained to think aloud, and had practice at it. There were still occasions, however, when thinking aloud appeared to be difficult to do at the same time as thinking, and in these cases he relied on discussion afterwards. De Groot (1965) criticises Duncker's over-optimistic treatment of the difficulties inherent in 'thinking aloud' (Duncker 1945). The major difficulties he discusses are incompleteness of the protocol, and interference with the solution process. De Groot's solution was to 'interrupt the subject...
occasionally and ask for an introspective report and to supplement longer solution protocols with shorter problems that could admit a reasonably complete retrospective account.

With more preparation of students, selection of problems, and supplementary studies, it is possible that this method of 'thinking aloud' could have been used successfully for studying problem-solving. My own difficulties with it, together with my doubts about its validity as an account of the solution process, reinforced by the researchers mentioned above, led me to drop this method from later studies.

On the other hand, the feasibility study did demonstrate that students were able to give detailed accounts of their performance on a task after it was completed, and that these accounts were analysable according to the characteristics of learning described, for example, by Pask. This encouraged me to use the technique with more students in later studies.

3.3. **Stage B: Pilot Stage**

There were three main aims in the pilot stage: to attempt the replication of some of the research studies that had produced informative descriptions of student learning; to study the application of these descriptions to students' normal work; to undertake a more exploratory study of student learning and thereby increase the range of possible parameters to be studied. Each type of study, replication, extension, and exploratory, will be described in detail. Some of the component techniques of data-gathering, analysis etc. need some discussion first, however.
3.3.1. Research Techniques

3.3.1.1. Choice of students

The seven students taking part in this study were from four science and engineering departments—Electrical Engineering, Physics, Chemistry and Bio-Chemistry. The form of the study was a series of in-depth case-studies of these students, where each one took part in five 1-hour sessions over a period of 4 - 5 weeks.

Since the overall aim of the study was to investigate the parameters of student learning, and the existing research studies on which it was based were subject-matter independent, it was possible to include students from several departments, rather than concentrating on one particular subject area. At this stage there was no reason to study one particular group of students. For the replication and extension studies, the descriptions being used were sufficiently generalised to be applicable to all these students. For the exploratory study, its very open-endedness meant that it placed no restriction on the choice of students.

It seemed advisable, however, to restrict the choice to science and engineering students, since they were engaged in similar kinds of activities—problem-solving, writing up laboratory practicals etc.—whereas arts and human science students cover a range of completely different activities such as discussion and essay-writing. The replication of the problem-solving study would not have been appropriate with these students.

In using a series of in-depth case-studies it was possible to attempt to account for why students were using particular learning techniques. The aim of the study was not to give simplified descriptions of student learning in general, but to use a small number of students in the hope of gaining insight...
into the kinds of conditions that are important for learning, and how it operates when it does take place. Detailed studies of these individual students working in a number of different tasks could provide a rich source of ideas on the parameters of learning and various relationships between them.

3.3.1.2. Open-ended interviews

The purpose of the open-ended interviews was to explore the students' experiences of learning via their own accounts of these experiences. This was to counteract the effect of the highly-focussed replication studies by allowing the emergence of new types of variables or parameters or descriptions of learning. It was therefore important that the interviews should be directed more by the student than by the interviewer, who should endeavour to follow up points made by the student and avoid directing him in any way. Since the interviewer wants a particular type of information, however, the actual questions asked have to be carefully considered.

Two studies which have made extensive use of open-ended interviews with students are those by Perry (1970) and Bliss and Ogborn (1977). Both confronted the fact that it is difficult for the student to know what to talk about if he is not asked specific questions. In both studies, the interviewers devised questions that would enable students to give specific answers, and yet did not direct the nature of the students' replies. In Perry's study of students' intellectual development, he asked, for example, "Why don't you start with whatever stands out for you about the year?"

In Bliss and Ogborn's study of students' reactions to undergraduate physics, interviewers asked students "to tell of a time when he or she had felt particularly good or particularly bad about anything at all to do with learning at the university." (Bliss & Ogborn, 1977). Both types of question ensured that the student would be talking about experiences that were relevant to the study, and they also induced the student to talk about specific instances, rather than generalities.
The same considerations were important for the present study. It was essential not to allow the student to talk in generalities, but to give specific instances, specific examples of any experience he referred to. The form of the interview therefore combined the two approaches above.

At the start, students were told the aim of the study: "to try to identify and describe the ways in which students go about their academic work, the ways they learn, study, revise, or whatever else they do as part of their course". It was this introduction that told the students what they were to talk about. After this, the first question was always "Tell me how it's been going this year." For most of the remainder of the interview, the questions could be simply asking for clarification, e.g. "What do you mean by ....?" or asking for examples, e.g. "Can you remember a particular occasion when that happened?" By continually following up a student's comments, however, it is possible for the interview to pursue a particular topic to the exclusion of all others. This did not happen often, as the students' answers were usually so rich in content that it became impossible to follow up every thread, and some bias was no doubt introduced in the selection of points to follow up. If a student kept strictly to one topic, however, and apparently finished talking about it, the social constraints of the situation demanded that the interviewer select a new topic. This was done as naturally as possible, and keeping within the area referred to in the introduction, e.g. "What about revision?" or "What are the lecturers like?"

All interviews of this type lasted approximately 30 - 40 minutes and were recorded with the students' consent. They were then transcribed for later analysis.

3.3.1.3. Transcription

At the early stage of the study, all interviews were transcribed verbatim. As the study progressed and the analysis developed, only relevant sections
of interviews were transcribed, again verbatim. The transcripts recorded everything the students said, including 'ums' and 'ers' and false starts. To begin with, they also recorded any noticeable pauses ('long pause' for those greater than 15 seconds). These were later omitted as they added nothing to the analysis. The transcripts thus obtained were complete records of everything the student actually said. In using quotes from students as supporting evidence in the later chapters, the verbatim quotes have been edited for the sake of greater clarity. An example of this is given below where the complete extract is a verbatim transcript from an interview, and the edited version is underlined, omitting repetitions and irrelevancies.

"I: "... do you use different revision techniques for revising for calculation types of things, or don't you bother to revise for that sort of thing?"

S: "For calculations, I use the writing out thing to, to get the formulae, um, then have a bit of a mess around putting different numbers in, just to make the units, make sure the units are, um, sort of or fixed, and um, just to, to see how the thing, ah this is very, this is if I have time. It's more or less a case of just learning the formulae if it's a lack of time. If there's time certainly try a few different numbers in, in a problem, and go through model answers. That again is, a I think is a most, um useful way of learning how to do a calculation, is going through a model answer. Cos if, if I, um, am forced to go through a calculation problem from beginning to end on my own without any, any guideline, when I do, when I do it for the first time, I find that I tend to get completely lost in it quite quickly, even though I can, I know how to do it, but, some small little problems build up very quickly, and er, that's it, I've lost interest in it, it's gone."

Throughout the following chapters, transcripts such as the above edited version will appear as continuous, with no points (...) to indicate omissions, or square brackets to indicate insertions. This aids reading, and in no instance is more distorting of the original meaning than the above edited passage. In cases where points do appear, this is because a considerable amount of speech separates the two parts. The student may have returned to the same point later in the same interview or may have digressed for some time. Relatively trivial omissions such as those in the passage above are not indicated.
Later in the study, as the analysis developed, not all the interview data was transcribed verbatim. The analysis suggested which sections of each interview would be relevant to the study, and only these were transcribed.

3.3.1.4. Analysis and reporting back

Methods of analysis for the replication studies were straightforward as these were predetermined. Minor difficulties, that arose as the result of ambiguities in the published reports, are discussed in Chapter 4, under each study, as relevant.

The major effort of analysis in the pilot study was directed to the open-ended interviews. The point of these interviews was to provide background data on the students' general perceptions about their academic work, within which the replication results could be interpreted. The interviews were purely exploratory and as such required an intrinsic analysis, rather than one based on previous work.

The process of reducing such data to its essential elements is one that has few precedents in educational research. We need to look to the methods of social psychology for comparable techniques. Glaser (1969) describes the 'constant comparative method' for analysing qualitative data in such a way that it can help to generate theory without having to fulfil the conditions necessary to test theory, e.g. it does not have to take account of all the data. The value of the 'constant comparative method' is that it allows the researcher to systematise his analysis - it is not just inspecting the data - but it does not require the coding of all relevant data, as would be necessary for hypothesis testing.

The method is not fully transferable to the present study however, as it does begin with some 'givens'. To employ the method, the researcher must
have already established a number of categories (Glaser's examples are 'social loss', 'professional composure') and can generate the properties of these categories by comparing incidents applicable to each category. It is the process of comparison that generates the theoretical properties of the category.*

In the present study, however, there were no 'givens' such as theoretical categories, but the method of analysis developed attempted, like Glaser's, to be both systematic and generative, and could benefit from the idea of constant comparison, if not from the details of the method.

Each interview was transcribed verbatim. 'Categories' were generated by considering each separate point a student made, that seemed relevant to the aim of the study. Depending on the verbosity, repetitiveness and self-awareness of the student this might be every sentence, every paragraph or just occasional remarks. Each one was listed in chronological order for one student, checking for repetition of the same point, or expansion of a previous point. Each successive transcript was analysed cumulatively, in the same way, so that a large number of general points covering several quotes were built up. For example, the first student made the point:

"If I can't do something, I try, then leave it."

A second student talked about the same point, but in a different way:

"If it's not clear, I go to the tutor".

Two further students made related points:

"If I don't understand it, I find a similar problem"

"If I don't understand it, I go to the lecturer".

Thus by comparing statements on the same point it is possible (a) to build up a list of the major points made by the students (e.g. how they cope with not

* This is a similar mechanism to that used in the reportory grid technique.
understanding something) and (b) to analyse the differences between the students on the various points.

The transcripts of interviews with the seven students generated 110 general points, initially. These could be categorised by inspection according to the kind of area of the student's work they referred to. The overall grouping of categories was thus reduced to 'teaching', 'motivation', 'university', 'study methods' and 'subject'.

Further discussion of the results of this analysis will be dealt with in Chapter 6. At the end of the pilot study, the results were written up as a report that was circulated to the students taking part, and elicited comments from two of them. The report back to students was seen as an important part of the procedure. All the students had expressed an interest in the study as they progressed through the various sections. Many of them offered comments and suggestions that were very helpful. It was important, therefore, to build these into the development of the study.

3.3.1.5. Selection of quotes

A major problem in the analysis of interview data is the selection of quotes to be presented as evidence. Part of the analysis aims to demonstrate the existence of certain parameters of learning, or characteristic descriptions that can be applied to students accounts of their experience of learning. The point being made in this case is essentially a positive one i.e. it is enough to show that the characteristic description is applicable. It is not an exclusive point requiring negative evidence e.g. to show that a student uses only one type of description would require evidence of the absence of other types of description. But when the point of the argument is that certain characteristic descriptions occur, it is sufficient to select quotes that demonstrate only this.

* See Appendix 1.
The analysis of interview data also aims to demonstrate the existence of relations between characteristic descriptions of learning. Sometimes these may be explicitly stated by the students, but more usually they are derived from the student's complete account of, for example, a particular learning experience. In this case, relations have to be established by considering individual case studies, which take into account all the points a student makes about that particular situation. Analyses of this kind are discussed in Chapter 6.

The remaining problem with using interview data is the interpretation of the students' accounts. Where particular characteristic descriptions are being applied the data has been analysed by a second judge to provide a check on interpretation. Altogether three other judges were used to cover a reasonably large sample of the total data analysed (approximately 25%).

3.3.2. Replication Studies

3.3.2.1. Replicating Bruner's work on Concept Acquisition

The procedure here followed Bruner's as far as this could be known from the published text.*

The original experiments were done on the study of selection strategies with 12 undergraduate students. To formalise the study of concept selection strategies, he used an array of cards (see Fig. 3.1.) with patterns which differed in the attributes of shape, colour, number of figures and number of borders.

Fig. 3.1. An array of instances comprising combinations of four attributes each exhibiting three values.

The experiment was conducted as follows:

"We explain to the subject what is meant by a conjunctive concept - a set of the cards that share a certain set of attribute values, such as "all red cards", or "all cards containing red squares and two borders" - and for practice ask the subjects to show us all the examplars of one sample concept. The subject is then told that we have a concept in mind and that certain cards before him illustrate it, others do not, and that it is his task to determine what this concept is. We will always begin by showing him a card or instance that is illustrative of the concept, a positive instance. His task is to choose cards for testing, one at a time, and after each choice we will tell him whether the card is positive or negative. He may hazard an hypothesis after any choice of a card, but he may not offer more than one hypothesis after any particular choice. If he does not wish to offer an hypothesis, he need not do so. He is asked to arrive at the concept as efficiently as possible. He may select the cards in any order he chooses. That, in essence, is the experimental procedure."
In the replication study, I used the same procedure. For the selection strategy, the seven students were shown an array of cards (see Fig. 3.1.). They were given a sample concept, with positive and negative instances, i.e. they were told that for the concept "Black squares", the cards '1 Black square, 2 borders' and '3 Black squares, 1 border' would be positive instances, while the cards '2 Black circles, 2 borders', '2 grey squares, 2 borders' would be negative instances. They were then asked to guess at the concept assigned by the experimenter, by asking whether a particular card was an instance or not. The student was told he could guess at the concept at any time, and could take any number of instances. The cards selected by the students were recorded, together with the point at which they made a guess at the concept. This continued until the concept was correctly guessed. In one case the student gave up after feeling he was lost, and the task was repeated with a different concept. Each student did 4 or 5 conjunctive concept tasks (as opposed to a disjunctive, e.g. 'either squares or circles') and was asked after each one to describe briefly how he had approached it. This was to aid later analysis.

For the reception strategy tasks, only part of Bruner's experiment was repeated. Here the student was presented with a series of instances, both positive and negative, and was asked to deduce the concept. Each card was presented at approximately 10 second intervals, and the student was told whether it was a positive or negative instance. After each card, the student wrote down his best guess at the concept, and these protocols provided the data. Again, after each task, the student was asked to explain his approach.

Each student completed five reception tasks each with a total of 12 instances. Bruner extended this to concepts with 6 attributes instead of 4, which allowed more complex problems in reception strategies and also allowed a wider range of concepts than was possible with 4 attributes. However, since his results
applied to both conditions, the simpler one was deemed to suffice for the purpose of replication. The results of this study are described in Chapter 4, section 4.2.

3.3.2.2. Replicating Thorsland and Novak on problem solving

The procedure adopted here followed that described by Thorsland and Novak (1974). In an experiment with 25 undergraduate physics students, they gave the students four physics problems to solve, and interviewed them on their solution process. All interviews were tape recorded and then analysed according to the definitions of 'intuitive' and 'analytic'.

In the present study, I followed the same procedure, except that
(a) students were given 2 of the 4 problems, and
(b) only one judge analysed the protocols.*

Students were given one problem at a time (for problems see Chapter 4) and were told they could take their own time, and would afterwards be asked to explain their approach. The students took 2 - 15 minutes for each problem, and their subsequent oral explanations were recorded. Any notes they made were retained for later analysis. In the interviews, students were asked first to explain how they went about the problem, and then any necessary supplementary questions were asked, until each step of their work had been described in detail. The transcripts of these interviews provided the data for later analysis.

A further difference from Thorsland's interviews was that students were not guided towards a correct solution, but were simply asked to explain whatever solution they had, even if it was wrong. They therefore received no external guidance to bias their thinking. It is not clear from the paper whether Thorsland and Novak used the guided solutions in their analysis, or whether

* Parts of the analysis were subsequently corroborated by Novak, see Appendix 3.
this was done simply for the students' benefit. Presuming the latter, this aspect of the procedure was effectively identical as far as the analysis was concerned. The results of this replication study are described in Chapter 4, Section 4.3.

3.3.2.3. Replicating Marton's studies of reading

In order to replicate Marton's work on reading, it was necessary to select a text that was meaningful to the students, but unfamiliar. A text that fitted these criteria and was about the right length, was Russell's essay "Can a scientific society be stable?" The students were given the text, asked to take their own time to read it, and were told they would afterwards be asked to summarise it and would be asked questions on their approach. The students took 15 - 25 minutes to read the text, and as soon as they finished, were asked to summarise it in their own words. This provided some information on the 'outcome of learning'. They were then asked specific questions on how they approached it:

How did you go about reading it?

Did you skip anything/read anything more than once?

If so why?

Did you think about anything else while you were reading?

Did you refer back to earlier parts of the text?

All students were asked questions of this form, together with requests for clarification, or examples of what they were talking about. The latter is particularly important as students, in talking about their work, make as many throwaway generalisations as anyone does in ordinary conversation, and when they are asked to instantiate them, may have some difficulty in doing so. For example, if a student says 'I work every evening' it can be illuminating to both interviewer and interviewee to ask when they last worked in the evening - last night, the night before? In the reading task, instances of their generalisations could lead to very detailed accounts of their approach, and were therefore very useful (see Chapter 4, Section 4.4.2.).
Since all students in the pilot study did this particular task, it was possible to compare performances. However, it was also important to see whether the findings on the Marton task carried over to the students' normal work. They did a second reading task, therefore, but this time the text was from their own coursework. This is described as part of the 'extension studies' following.

3.3.3. Extension Studies

3.3.3.1. Extension of Marton's study into normal work

Students were asked to bring with them a piece of text they were reading as part of their course, that they had not already looked at, and that would take them approximately 20 minutes to read. Since all the students were science and engineering students, the text was in all cases from a text-book, and in all cases no longer than three pages (as opposed to the 2000 words of Marton's text, and the 1500 words of the Russell essay).

The students were asked to take their own time, and were told they would be asked to explain their approach. Once again, they took 15 - 25 minutes to finish, and were immediately asked to summarise what they had read.

The same questions on reading were asked, as before. In addition, the students were asked specific questions about the course within which they were studying the topic, and their reasons for reading it:

Why are you reading this?
What is the rest of the course like?
What will you do on this now?

The remaining questions were follow-up questions to these which depended on the nature of the answers, but were designed to establish as full a picture as possible of how this particular piece of work fitted into the student's
work as a whole, and what, if anything, was influencing it.

All interviews were recorded and transcribed for later analysis. The results are described in Chapter 5, Section 5.2.2.

3.3.3.2. Extension of problem-solving studies into normal work

In the same way as the reading studies were extended, the problem-solving studies were also extended into normal work. Where the replication of Thorsland and Novak provided a comparison between students working on the same problems, the extension study would give a full picture of the background to each student's work on a specific problem.

Students were asked to bring problems that were part of their course, that they had not yet done, and would take them about 20 minutes to do. They did not always finish as some problems were quite long and complex. However, the student had usually done enough to be able to talk at length about his approach.

As in the reading tasks, the student was asked to work at his own pace, and was told he would be asked afterwards about his approach. As soon as he had finished he was asked to explain briefly what the problem was about. On their approach to the problem, students were asked:

- How did you go about it?
- How did you start?
- Was any part difficult - why?
- Did you refer to anything else?
- What will you do on this now?

As before, further questions were asked about the context within which they were doing the work.
Interviews were recorded, and written work and copies of the problems were kept for later analysis. A full report of this extension study appears in Chapter 5, Section 5.2.

3.3.4. **Exploration Studies**

3.3.4.1. **Student-directed learning**

Some of the research studies in programmed learning which have looked at 'student-directed learning' (Campbell, 1964, Mager & Clark, 1963, Issing & Eckert, 1973) suggested that this kind of technique could show up differences in students' approaches to learning. In these experiments, the first used written material, and the latter two, a teacher as the instructional resource. Within the programmed learning studies the main interest lay in the nature of learner controlled sequences, i.e. the fact that they existed at all, and that they differed from instructor-controlled sequences rather than in the differences between different learner-controlled sequences. The nature of the individual differences were not reported other than to say the order of the sequence was different, and therefore could not be replicated. But an attempt at replicating the method was made in the hope that it would produce some recognisable differences that could be compared with the others being investigated. The method was not a success, however.

Comparisons between students could only be made if a single topic was used, so one was chosen that had some relevance to all the students, but was not familiar to any of them. Since I was acting as both experimenter and instructor, the topic had to be familiar to me. One topic that satisfied all these conditions was the operation of the electron microscope. Thus students were told the objective: to be able to explain the operation of the electron microscope, and they then asked questions in order to obtain the information they thought necessary to achieve this.
There were indeed considerable differences between the students in the order of the questions asked. But there were also differences in the kind of questions asked. Some students were happy with a lower order of complexity of explanation than others. Some concentrated on different aspects of the mechanism, e.g. structure, or function. The small number of students did not allow a full analysis, especially as this was being done from scratch, with no previous results to base the analysis on.

Further problems arose concerning the nature of the technique. It was clear that a subject expert would be necessary to handle the wide range of questions being asked, some of which could be very fundamental. Unlike the other replication studies, the technique could not easily be transferred to normal studies because it would be necessary to interrupt the normal teaching to replace it with this type of student-directed learning.

It is therefore a technique which although potentially very fruitful, needs to be carried out with care and with the full co-operation of all the participants on a single course. The technique was not repeated later in this study.

3.3.4.2. Results of the pilot study

The results of the pilot study are discussed in detail in Chapter 4. The relative failure of the replication studies, and success of the exploratory and extension studies meant that the latter two were developed further for the beginning of the major part of the study. The report on the pilot study included an initial attempt to summarise the results in terms of a model of student learning. The major components of the model, namely 'the university', 'overall motivation', 'teaching', 'study methods' and 'subject' were used to generate details of the methods developed for the next phase of the study. The development of the model will be described more fully in Chapter 6, Section

* Discussed in Chapter 4 in sections referenced above.
The aim of the main study, based on the results of the pilot study, was to gather more data on students' study techniques together with information about the circumstances in which they were used. The interpretation of this data could then contribute to the development of a model of student learning.

Both the exploratory, open-ended interviews, and the interviews on normal work (problem-solving and reading) were continued. In addition to these, three new techniques were introduced in this study, which are described below.

The ten students involved covered a range of departments: Physics, Chemical Physics, Human Biology, Electrical Engineering, Civil Engineering, Chemical Engineering, Mechanical Engineering, Biochemistry and Mathematics.

3.4.1. Research Techniques

3.4.1.1. The 'written interview'

One of the main advantages in this kind of research that makes such extensive use of transcribed interview data, is the time-consuming process of transcribing. In order to reduce this, I tried a new technique that aimed to retain the open-ended, interactive qualities of the interview, while making use of the convenience of the questionnaire.

From the open-ended interviews of the pilot stage, a number of areas of major importance had emerged as being common to all the students. These centred around the topics:

- Why they had chosen to come to university.
- What they thought university was for.
- Why they had chosen their subject.
- The different reasons they had for working.
The different ways they approached their work.

It was clear from the ways the students had talked about these aspects of their academic life that these were questions that should be asked of all students. The questions did not lend themselves to questionnaires, as they demanded complex answers, but it seemed possible that students could write down their answers instead of speaking them.

The students were given the five questions and asked to write their answers down on a separate sheet of paper, taking as much or as little space and time as they felt necessary. Since I was present the students were able to query any ambiguities in the questions, and I was able to query the students' written replies when necessary. Students did not in practice, query the questions, but occasionally I found their answers were too brief, and asked them to elaborate what they had said. Thus the procedure certainly retained open-endedness; it also retained some interactiveness. An additional advantage was that students could read over their replies during a later session to check whether they still thought them representative of their feelings. None of the students changed what they had written, but one student took the opportunity to add something.

A check was provided on the extent to which this technique was capable of replacing the interview, by using it in the session following the open-ended interview session. In those cases where the topics had not arisen in the first session, the technique provided the necessary supplementary information. In the cases where the topics had arisen, the 'written interview' provided a very concise summary of the points made by the student in the interview. The replies never conflicted, although, naturally, the interview was richer in detail, and the same questions therefore led to other interesting points about the students' approaches to work.
The 'written interview' technique, used in this way proved to be a valuable supplement to the open-ended interview by dealing with the structured questions generated by previous interviews. If the 'written interview' is given first, of course, then the students written comments can be followed up where necessary in the open-ended interview if more richness of detail is desirable. The technique was used throughout the remainder of the study.

3.4.1.2. Interviews on academic history

During the pilot stage, a number of students had talked about the development of their study methods during A-level, and later at university. It was possible, therefore, that a retrospective account of a student's development of his study methods, together with more general background information on the various decision points in his school career, might be useful in explaining aspects of his current study methods.

These interviews worked backwards from what I already knew about the student's work from open-ended interviews, attempting to tell the story of his academic development in terms of why he made certain decisions and how his attitudes and study methods had changed.

These interviews provided rich data on the students' academic development. However, the information was of a different type from that obtained in the remainder of the study as it was longitudinal rather than what might be called 'latitudinal', or cross-sectional, i.e. across the range of the student's current work. Clearly a complete profile of an individual student's perception of his academic work could make use of this kind of information, but it played a small part in the overall analysis. The inclusion of this kind of data proved too ambitious a task for the present study, as it requires a more detailed longitudinal study.
3.4.1.3. Model-building

As part of the aim of the study was to develop further the model of student learning through the medium of the student's perception of his academic work, I designed a technique that would make more direct use of the student's perceptiveness in the actual development of the model. A similar technique has been adopted in the field of academic gaming, where Gibbs (1974) designed a game to allow students to develop their conceptual models of physical concepts. The students were given cards with the names of concepts written on them (e.g. 'force', 'pressure', 'motion' etc.). They could then arrange these into a 'map' using connecting arrows to indicate the nature of the perceived relationship between the various components. The value of the game in teaching was that it stimulated discussion and allowed students to articulate their ideas about the nature of these concepts.

I adopted this technique as a way of gaining access to the kind of models the students had of their academic life. The instances were chosen from the numerous points made by the students during interviews, which fell within the different components of the postulated model, e.g. under 'subject', there were some twenty descriptions covering a wide range: "the subject is very mathematical", "the subject is all concepts", "the subject is very easy". Everything each student said, that was relevant to the components of the model, was represented on a card. The students were given a large diagrammatic representation of the postulated model, (see Fig. 3.2.) and were asked to select instances of the general components (teaching, subject, study methods etc.), using the cards, for a particular subject and teacher. The students could make up extra cards and insert or delete connecting links if necessary. The connecting links between components were directional and were to be interpreted as "influences" or "is influenced by" depending on the direction. Each student's interpretation of the model was recorded using numbers on the cards.
The technique had potential as a way of elucidating students' perceptions of their academic work, but it was too ambitious to be attempted at this stage. The model was still highly tentative, and with the incorporation of the new data from stage 3 had become too complex for this method to work well. The students enjoyed the exercise, and it led, through discussion, to further insights into the factors that affect student learning, but it did not fulfill the aim of helping to develop the model. The lesson learned from this
attempt was that the method was extremely difficult for the student, and required practice and, probably, repeated attempts. One hour was not sufficient to work through all the complexities. The technique was therefore, regretfully, abandoned for the present study.

3.5.  **Stage D: Continuing the Main Study**

As may be seen from Table 3.1., the successful techniques of Stage C were carried over into Stage D, with only one new addition, the method of 'teachback'.

By this stage of the study it had become clear that an important part of the analysis of student learning consisted in exploring the context within which learning took place. It was therefore necessary to devote one stage of the study to the investigation of student learning within a particular department. Ten students from the Department of Metallurgy and Materials Technology took part in this stage. The investigation focussed particularly on one group of lectures (crystallography) and I attended those lectures in order to collect additional background data to the students' own accounts.

3.5.1.  **Research Techniques**

3.5.1.1.  **'Teachbacks'**

Extensive data had been collected, in previous stages of the study, relating to students' perceptions of their academic work. In addition to this, it was important to elicit not only data on the students' descriptions of their thought processes, but data on their actual thought processes as well. The technique I used to do this, was suggested by a technique used by Pask in his study of serialists and holists. Given written material, in programmed
had to 'teach back' the material to the experimenter. Holists and serialists differed in several features of their 'teachbacks' particularly in the amount of disruption of the original order, and in the amount of irrelevant or redundant information included.

The method of 'teaching back' material that has already been assimilated by the student is one that is certainly applicable to students' normal work as any one topic is usually well-defined and can therefore be summarised by each student in such a way that his account will be comparable with the other students' accounts, at least for range of content. Within-student comparisons can also be made by investigating each student's accounts of several different topic areas.

Students were asked to bring any notes they needed in order to explain a topic of their choice. The only constraints were that the topic should be something they were currently working on, and they should spend around twenty minutes in explaining it. In fact explanations varied in length from 5 to 20 minutes. At the beginning of the session, each student was asked:

"Could you explain this topic to me as though you were teaching it to me, assuming I know nothing about it, start right from scratch".

After the student's initial explanation, I asked questions to (a) resolve any apparent contradictions in what they said, (b) elaborate a point that had assumed special knowledge on my part. It was important to avoid introducing any new content in asking a question, although it may do so indirectly. It was also important to avoid introducing a different style of explanation. Questions could be used to elicit the fullest possible explanation, but only as long as it was in the student's own terms.
When the explanation, or 'teachback' was finished, there followed the usual interview about the circumstances in which the topic was being studied.

There are two main problems with the teachback technique used in this way. The first problem is that it is impossible to guarantee that different students will choose the same topic. Since one condition is that the student should be working on the topic, the researcher cannot choose it. Interviews with 10 students inevitably extend over 1½ to 2 weeks, and this is too long to guarantee an overlap of chosen working topics. With 10 students coming to five sessions each, over a period of 8 weeks, only 50% overlap was achieved. The resulting amount of usable data provided several comparable accounts, and was sufficient for a full analysis to be done. The wastage rate is high, however.

The second problem with the technique concerns the interpretation of the protocols. To what extent do they reflect the students' learning processes? If a student is asked to explain a topic in his own words, to what extent does his account reflect the way he thinks about, or learns that topic? In his holist/serialist experiment Pask was able to identify holists and serialists independently and showed that the characteristics of their 'teachbacks' corresponded to their assigned types. This is the only experimental justification for the assumption that the two processes (of learning and 'teaching') are related. This technique suffers from the same problem of interpretation as every (test) of learning style, in that it is impossible to take into account the aims and expectations of the student in that test situation. If the student understands the instruction as 'teach this to me the way you were taught it', for example, he will explain it differently from when he understands the instruction as 'teach this to me the way you would have liked it taught to you'. The problem is not quite as severe in this particular test situation as it is in many others, however, as the aim was
not to test the students' learning styles, but to establish whether previously established learning styles were applicable to the way students talked about their normal academic subjects. While it may not be possible to use these protocols to discriminate between students according to their style of learning, therefore, they may be used to investigate the extension of Pask's descriptors into normal academic work.

The analysis of these protocols was based on the characteristics of 'comprehension' and 'operation' learning as described by Pask and others in the published literature. This is described more fully in Chapter 5, Section 5.3.5.

3.6. Stage E: Replication of Pask's Work

Pask's most widely used test of learning style (Pask 1977) is the Spy Ring History Test. The test was designed to discriminate between students according to their bias towards operation or comprehension learning. Pask & S have suggested (1972) that science students tend to exhibit bias towards operation learning as this is particularly important in science subjects. However, they also point out that both styles are essential for understanding. The aim of this replication study was to ascertain the extent to which these science and engineering students did exhibit a bias on the Test, and to establish whether or not the same bias could be identified in the 'teachback' accounts of their normal work.

3.6.1. Research Techniques

3.6.1. Spy Ring History Test

The test materials (see Appendix 5) were obtained from Professor Pask, and
his colleague Elizabeth Pask administered the test during the first group session. This enabled me to take notes and subsequently administer the tests in the same way to further groups of 1–4 students. On two occasions, students found the pressure and covert competitiveness of the group test not to be conducive to a good performance, and these students repeated the test on their own. I marked all the tests according to the standard scoring procedure, and these were checked by Pask's colleagues.*

In order to assist the interpretation of the scores, students were asked to give written accounts of their reactions to the test, and brief accounts of how they had approached it. The format of these questions was derived from my interviews with the four students of the first group session. All their accounts were written immediately following the test. The results of this test, and the students' written accounts are discussed in detail in Chapter 5, Section 5.3.2.

3.7. Concluding Points

The development of the complete study is outlined in Table 3.1, and shows how the various techniques were used in the successive stages.

Throughout the study, I attempted to maintain a balance between the focussed, systematic replication studies and the more open-ended exploratory studies. This balance meant it was possible to provide some link between these two very different approaches to educational research. The aim of the replication studies was to establish the extent to which their results were applicable to science undergraduates. The extension studies went beyond this in

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* Bernard Scott & David Ensor.
attempting to relate educational research findings to the students' normal academic work. This part of the study was also systematic in both execution and analysis since it could, on the whole, follow previously established procedures. The exploratory studies provided a quite different way of looking at the same problem - student learning - and were used to put the various learning situations studied in their context. The relative failure of the replication studies* has meant that the major part of the analysis and results to be reported in later chapters will concentrate on the extension and exploratory studies. The two together will be used to elucidate the nature of the factors that affect student learning, and to attempt to develop a model of student learning in terms of these factors.

* Discussed in detail in Chapter 4.
4.1. Introduction

The primary aim of this chapter is to discuss the results and implications of a pilot study on seven science and engineering students. Given that the relevant literature on student learning (as discussed in Chapter 2) was divided between the identification of individual differences, and the identification of contextual influences on students' working behaviour, the aim of the pilot study was to span both types of investigation. On the one hand, it was an attempt at replication: to find out the extent to which established individual differences were applicable to these university science students. On the other hand part of the study was an exploratory investigation of the influences of contextual factors on these students. The four studies replicated are discussed here, with a general discussion of implications in the final section. The replication of Pask's work is described in Chapter 5, because it is closely integrated with the extension of his work into students' normal study.

4.2. The work of Bruner, Goodnow and Austin

4.2.1. The original experiment

In their book 'A Study of Thinking', Bruner, Goodnow and Austin, (hereafter referred to as 'Bruner') give an account of their work on concept attainment strategies with undergraduate students. The importance of this work is that it is an attempt to investigate, in a formal way, one of the cognitive processes that is crucial for high level learning. The aim of Bruner's work was to establish ideal characteristic strategies of concept attainment by looking at the formal characteristics of strategies used by students in a standard test. Within the results of his investigation, Bruner establishes some characteristics
that are consistent, but different, for individual students, and it was these characteristic individual differences that the present study aimed to replicate.

Bruner begins by assuming that concept attainment is a process involving decisions about hypotheses made on the basis of instances of the concept. Decisions are made, for example, about which attributes of each instance should be noted, about what kind of tentative hypothesis should be made, and about how to modify a disproved hypothesis. Regularities in decision-making of this kind are 'decision-making strategies' and these may be either 'selection' or 'reception' strategies. If the student can specify the sequence of instances he encounters, e.g. by saying "is this an instance of the concept?", this will be a selection strategy; if he can only decide how to use instances of a given sequence, e.g. he is told "this is/is not an instance of the concept", this is a reception strategy, which, as Bruner points out, is the type students most commonly have to use in their learning.

The first experiments were done on the study of selection strategies, where Bruner used 12 undergraduate students. The details of his method are described in 3.3.2.1. The analysis of sequences of the students' choices and guesses enabled Bruner to identify four different types of selection strategy. He does not describe how these strategies are arrived at, but it seems to be a combination of logically possible, idealised strategies, with the strategies actually used by the students.* The four selection strategies are defined as:

**Simultaneous Scanning** (Si.S): uses each instance to deduce which hypotheses are tenable and which have been eliminated.

**Successive Scanning** (Su.S): limits choice to instances that provide a direct test of current hypothesis.

* This was confirmed in a private communication (see Appendix 2).
Conservative Focussing (C.F): changes one attribute at a time in choice of instances.

Focussed Gambling (F.G): changes more than one attribute at a time.

The students used in Bruner's pilot study tended to be either focussers or scanners, with some slight variations on the above ideal strategies. Bruner continued with a follow-up study to ascertain the relative efficiency of these strategies by increasing the cognitive strain on the students by, for example, using a random array instead of the ordered array in Fig. 3.1.

With the experiments in reception strategies, Bruner presented the students with a sequence of instances, and told them whether each was a positive or negative instance of the concept. After each instance the student was asked to write down his "best guess at the concept". Again, from a combination of logical possibilities, and actual student performance, Bruner established two main types of strategy:

- **Wholist**: bases first hypothesis on the whole instance initially encountered.*
- **Partist**: bases first hypothesis on part of the initial exemplar encountered.

The results of this experiment with the students showed that 62% of the problems were begun with wholist strategies, the rest with partist strategies. Moreover, the students tended to be consistent in their approach, using the same strategy over 14 different problems. Again, one strategy was more efficient for certain conditions: the wholist strategy places less strain on the memory and was therefore more efficient when greater cognitive strain was introduced by reducing the time available for each problem.

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* This is a very specific definition of 'wholist' and is therefore a quite different use of the term from Pask's 'holist'.
It must be emphasised that Bruner's study was aiming to characterise strategies of concept attainment rather than to identify individual differences in students. But the results he reports indicate both that there are different strategies available in the process of concept attainment, and that individuals are consistent in their adoption of these strategies. If these characteristic differences are reproducible, it would be possible to compare them with other individual differences identified in the literature and so arrive at a fuller description of characteristic ways of thinking. For this reason, it seemed an important study to replicate.

4.2.2. The Replication

In attempting to replicate Bruner's study with the seven students in the pilot study, I used the same experimental procedures. At the end of the first experiment on selection strategies, each student was asked to explain his approach, and was then asked to decide which of Bruner's four strategies applied to him.

The analysis of results was done by using Bruner's definitions of the four strategies. He does not discuss the identification of strategies explicitly, which is unfortunate since the scanning and focussing strategies cannot be reliably distinguished on the basis of the students' sequences of choices. For example, if after an initial positive instance of

| 3 Black circles, 1 border |

the student tests

| 2 Black circles, 2 borders, |

is he a 'focus gambler' or a scanner testing the hypothesis 'Black circles'? This kind of difficulty is not discussed by Bruner and was overcome in the present study by asking students to explain their strategy after each problem. Their reported strategies could then be checked against the categories assigned to the students' sequences of choices. Table 4.1 shows that from the analysis of all four problems, each student used at least two types of
strategy, so that the results are much less clear cut than those reported by Bruner.

<table>
<thead>
<tr>
<th></th>
<th>Peter</th>
<th>John</th>
<th>Alan</th>
<th>Paul</th>
<th>Stephen</th>
<th>Richard</th>
<th>Rod</th>
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<tbody>
<tr>
<td>Simultaneous Scanning</td>
<td></td>
<td>✓</td>
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<tr>
<td>Successive Scanning</td>
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<tr>
<td>Conservative Focussing</td>
<td>✓</td>
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<tr>
<td>Focus Gambling</td>
<td>✓</td>
<td>✓</td>
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</table>

Table 4.1. Categories assigned to each student's sequence of choices over four problems.

Bruner is mainly interested in the nature of the strategies rather than the performance of individual students, but since he uses the fact that they can be reliably identified as using one particular strategy in order to test what happens to that strategy when conditions change, these results should be a lot more clear cut than they are. When students were asked to choose which of the four defined strategies applied to them, many of their replies indicate that they consciously vary their strategic approach, both within and across problems.

John: "I used conservative focussing mostly, focus gambling when my logic had been lost".

Alan: "Not focus gambling, certainly not. A cross between simultaneous scanning and conservative focussing - more those than the others".

Paul: "Usually I use successive scanning. I hope I try to choose one that will test the idea in my mind. I'm not simultaneous scanning. I suppose conservative focussing to a certain extent. You've obviously got to do successive scanning in some manner and I do that by changing one thing at a time".

Stephen: "I form a hypothesis and wait for a card to test it, but may miss some information on the way. I'm a mixture of scanning and focussing. Conservative focussing gives the best results".
Richard: "I wouldn't say I fit precisely. I vary them, but maybe one or more fits. You think about hypothesis, you eliminate, but you vary depending on what happens. Conservative focussing is the common scientific way. If you want to vary more than two each time you have to keep track more".

Rod: "Conservative focussing is the one I tend to do. It's easy to lose track if you do focus gambling. I think I did a bit of simultaneous scanning. None of them fit particularly".

The analysis of the raw data was confirmed by the students' retrospective accounts of what they did, and indicated that these different strategies do not discriminate between individuals - they seem to depend more upon the contingencies within each problem.

The possibility of there being individual differences in choice of strategy is not clarified by Bruner's experimental procedure in testing the effect of different test conditions on the various strategies.

In the first experiment, he takes seven 'focussers' and five 'scanners' and gives each one a problem to do in his head, without the array of cards being displayed. The focussers do well, one of the scanners discovers focussing, the rest "came to ruin". It can be inferred from this that students are reliably identifiable as focussers or scanners, and that they tend to be consistent - only one of the twelve changed his strategy.

In the second experiment, two groups of fifteen students were compared*; one group working from an 'ordered' array, the other from a 'random' array. The aim, here, was to compare groups, not individuals: "The question we were asking was this. What kinds of strategies would the two groups of subjects adopt?" The results showed that the strategy adopted depended on the conditions: "The successive scanning of the Random Group .... was well suited to the requirements of the task". Similarly, the focussing strategy of the ordered group "again suggests a nice adaptation to the structure and

* The subjects were working individually, as before. It was not a group exercise.
requirements of the testing situation". It can be inferred from this that
students tend to vary their strategy according to the conditions of the
task, and are not consistent in their choice of strategy.

A further difficulty of replication occurred with the experiments on reception
strategies of concept attainment. Bruner's experiment with 46 students
showed that about 62% of the problems were solved using a wholist approach,
and there was a tendency for subjects to be consistent in their choice of
approach. In contrast, the results of the present study showed that less than
25% of the problems were solved with a wholist strategy, and 3 of the 7
students varied their strategy. In fact the latter result is not so
surprising since Bruner's finding of a tendency to consistency is based on
the fact that 63% of the students solved 80% of their problems the same way.

To summarise this study: it seemed that from the way Bruner reported some
of his results, there were consistent individual differences in the students'
choice of selection and reception strategies. A replication of this result
would have been interesting as a comparison with other types of individual
differences. However, both the results of this pilot study, and a close
analysis of the implications of all Bruner's results, suggest that the types
of strategies identified do not discriminate reliably between students.
Bruner has successfully identified a variety of strategies that can be used,
and has analysed their utility in different conditions, but the apparent
spin-off of consistent individual differences has not been replicated. This
part of the pilot study was not, therefore, followed up.
4.3. The work of Thorsland and Novak

4.3.1. The Original Experiment

A second study that identifies individual differences in student learning is reported by Thorsland and Novak in their paper "The Identification and Significance of Intuitive and Analytic Problem Solving Approaches among College Physics Students" (Thorsland, 1974). In part, the study "represents an effort at the identification of specific individual differences in learning within one subject matter area". The second part of the study went on to relate individual differences to other learning-related parameters such as scholastic ability, and efficiency in learning. It was the first part of the study on the identification of individual differences that was repeated in this pilot study.

Thorsland and Novak report that in initial problem solving interviews "students proceeded in the problem solving encounters in two distinct ways. One approach, termed analytic (A) was characterised by a step-by-step analysis of the problem, very explicit in nature .... often accompanied by the use of mathematical relationships and symbols. A second approach, termed intuitive (I) was characterised by an implicit "feel" for the subject matter, with little or no conscious awareness of the steps used in arriving at an answer."

The intuitive/analytic dichotomy has been described by Bruner (1960), and also relates to Ausubel's subsumption theory. Given Ausubel's cognitive structure, with a hierarchical set of concepts (subsumers), Thorsland and Novak define the analytic/intuitive distinction as follows:

"The highly I individual, it is conjectured, would possess the superordinate ideas and high level subsumers necessary for him to move across the upper levels ... with frequent referrals to (and from) subordinate concepts. The highly A individual, it is conjectured, would be very effective at regenerating the lower level, subordinate ideas, and would therefore move primarily from the subordinate to the superordinate concepts."
In the original study, the students were given four physics problems to solve, and were interviewed on their solution process. The interviews were tape recorded and then analysed according to the definitions of 'intuitive' and 'analytic'. For each of the four problems, an I and A rating was assigned to give an overall score between zero and 20 on each dimension. The results they obtained showed that the 25 students were fairly evenly distributed across the two dimensions, where 7 were classified as high I, 7 as high A, 5 as high I and A, and 6 as low I and A.

There are two main problems associated with the replication of this study. One is the difficulty of interpreting the interview protocols according to the definitions of 'analytic' and 'intuitive'. In order to test the validity of their interpretations, Thorsland and Novak gave four of the protocols to three other judges and asked them to rank these according to the following definitions:

"Analytic approach: student proceeds a step at a time. steps are reasonably explicit. student often uses mathematics, equations or logic and an explicit plan of attack.

Intuitive approach: student tends to use manoeuvres based seemingly on an implicit perception of the problem. student may not be able to provide an adequate account of how he got an answer. student seems to grasp meaning or significance of a problem without necessarily relying on analytic means."

The judges agreed in their rankings on both dimensions (coefficient of concordance: 0.86 and 0.87) even though, as the authors point out, the intuitive dimension "seems to be related to fewer specific identifiable characteristics".

4.3.2. The Replication

In the present study, the same experimental procedure* was used with two of the problems:

* Described in Section 3.3.2.2.
"PROBLEM X: Two putty-ball pendulums each of length $L$ are initially situated as in Figure 4.1. The first pendulum is released and strikes the second. Assume that the collision is completely inelastic and neglect the mass of the strings and any frictional effects. How high does the center of mass rise after the collision?"

![Figure 4.1.](image)

"PROBLEM R: A hollow sphere is filled with water through a small hole in it. The sphere is hung by a long thread and set swinging. As the water slowly flows out of the hole in the bottom of the sphere, what, if anything, happens to the period of oscillation?"

Analysis of the protocols showed that only one student, Peter, could be identified as using an intuitive approach:

Peter (Problem X):
"To start with I was thinking about the pendulum swinging, and then suddenly it occurred to me that, I think it was something just ingrained that you never forget, potential energy ... . I thought immediately they were equal weights. I just thought, it just struck me it was $H/2$, as soon as I understood the question. It just seemed right they would end up halfway between the two."

Peter (Problem R):
"I remembered something about mass doesn't affect period. Then I had to think about it. If you can imagine, the water would keep moving. Therefore it would have the effect of lengthening the pendulum. The instant it comes out, there is still friction between the water and what is in the sphere, so the centre of gravity moves down, so it's more complicated than that ... . I originally remembered that mass has no effect. Then I just decided I'd thought about it enough. I think it was intuition rather than logical thinking."

Here the student could be said to have an "implicit perception of the problem" and certainly does not fit the analytic characteristics.
The interpretation of the analytic protocols reveals an interesting point not mentioned by Thorsland and Novak. Some students seem to rely totally on formulae, and if they cannot remember them, their solution breaks down. Others reason through step by step, using formulae as they need them. Both are clearly analytic, according to the definition, but this seems to be an important distinction. The following are examples of formula-oriented thinking.

John (Problem X):
"First I thought of \( PE + KE = PEH - KS \). Then I was confused. I thought of one side of the equation. To begin with it's all potential. So then I looked at the other side ... At the beginning I wrote down the potential energies, so then it reaches a maximum height, and you can work out the potential energy ... I hate these problems because you feel you should be able to do them straight off, so there is great psychological pressure on you. And every time you think, you think: 'I shouldn't be thinking about it, I should know it'. (Solution not completed).

Alan (Problem X):
"It's conservation of energy. Before the collision, the total energy is \( MLGH_1 \) plus zero. After the collision, at \( H_2 \), the total energy, which is potential energy is \( (M_1 + M_2)GH_2 \), so you can solve for \( H_2 \)."

Alan (Problem R):
"There's a formula for period that's not dependent on mass, but on length. I just remembered it."

Paul (Problem X):
"The first problem was trying to remember what a centre of mass was. Then you have to do a conservation of momentum, or something. I wondered if you could reduce it to a single particle problem with a reduced mass, but I couldn't remember the definitions." (Solution not completed).

Rod (Problem X):
"I vaguely remembered A-level physics - when the two masses collide, they act as one mass ... I got a bit bored with that after a while. I tried to put down some symbols: potential energy is \( MLH \), kinetic energy is a half \( MV^2 \) squared. When \( M_1 \) hits \( M_2 \), they move as one mass, the kinetic energy of the system stays the same. I was thinking I probably had the principle right even if not the final answer." (Solution not completed).

Rod (Problem R):
"There's not much to get your teeth into. You either know the answer or you don't. I think. I have a block against this kind of problem ... I go by the way the question is put. If there were some symbols, I'd start thinking in terms of formulae." (Solution not completed).
All these students are highly dependent on formulae for their solutions, and the mechanical nature of this type of approach is revealed when the formulae are not available, and no alternative approach is attempted.

In contrast to this, some analytic solutions do employ some explicit reasoning. The characteristic of these solutions is that there is something more than the simple application of formulae; the formulae are interpreted, assumptions are considered, reasoning is based on what is happening in the system.

Peter (Problem X):
"You start off initially with potential energy, for M2 that's zero. The potential energy you start with is H times M1, you've got to end up with that. And the energy you've got at the end is M1+M2 times the height, I call X. So I worked the equation out."

John (Problem R):
"As the water flows out, the mass is reduced. The force acting on the sphere is due to gravity. So the reduced mass has no effect, since the effect balances."

Paul (Problem R):
"You could work this out from first principles. You know from experience it is like a pendulum. Does it decrease? Working it out, yes, thinking of the formula, I think frequency varies as length, so as length decreases, frequency decreases."
(Solution not completed).

Stephen (Problem X):
"From what I knew, the energy before equals the energy after, so M1GH1 equals (M1+M2)GH2. You can assume the masses amalgamate so you can just solve for H2."

Stephen (Problem R):
"The formula for the frequency of oscillation is one over 2pi, root k over m. Since none of the terms depend on the length, the frequency must be the same before and after."

Richard (Problem R):
"There is no change in the oscillation if there is no friction, or air resistance, and the string is non-elastic, - in effect an ideal system ... There is a shift in distance and the period becomes longer as the distance is increased ... Depending on the ratio of the mass of the sphere to the water, the length will first increase and then decrease, but won't ever be shorter than the starting length."

Most of the solutions to these problems were, in fact, incorrect. Although they fell within the range of capability of these students, all of whom had
done at least one year of an undergraduate physics course, they were not
the kinds of problems that any of them had done recently. They were having
to recall work from several terms before. This may account for their
rather poor performance. This does not, however, affect the interpretation
of their approaches to the problems.

From the above data it seems that it is possible to identify some of the
characteristics of the analytic and intuitive approaches defined by
Thorsland and Novak. It is also possible to identify different types of
analytic approach. The source of these different approaches, is more
difficult to ascertain, however, and it is at this point that the second
major problem becomes apparent.

In their identification of the analytic/intuitive distinction, Thorsland and
Novak began by relating this to Ausubel's notion of cognitive structure.
According to this, a student may work primarily with subordinate concepts
or with super-ordinate concepts. However this theoretical framework is not
used in the working definitions of intuitive and analytic. They have not,
for example, identified the subordinate and superordinate concepts involved
in each of the problems. The highly intuitive student is conjectured to
have the kind of cognitive structure illustrated in Fig. 4.2.

![Diagram]

High Intuitive Individual Moves Freely From One Superordinate Concept to
Another with Frequent Referral Primarily TO (and less frequently FROM)
Subordinate Exemplars.

Fig. 4.2. Representation of the conceptual organisation in cognitive
structure of the high individual (sic) and the relationship to
cognitive functioning.
The definition of the intuitive approach already quoted makes no reference to the use of superordinate concepts. Similarly, the analytic definition refers to step by step solutions, but does not specify the relative level of the steps involved. They may, presumably, go 'step by step' from one superordinate concept to another, but the highly analytic student should only move from one subordinate concept to another or to a superordinate concept, as shown in Fig. 4.3. There is, therefore, no relation between the working definitions of intuitive and analytic, and the conjectured source of the distinction. This point is also not discussed in the fuller account in Novak (1977).

![Diagram](image-url)

**High Analytic Individual**: Moves primarily within subordinate concepts and to superordinate concepts, with referral back to subordinate concepts, thus expanding the superordinate concepts. (Very little, if any, exchanges between superordinate concepts.)

**Fig. 4.3.** Representation of the conceptual organisation in cognitive structure of the high individual and the relationship to cognitive functioning.

Thorsland and Novak have identified two dimensions of thinking along which students can be placed, with some degree of reliability. Students may be intuitive, or analytic, or both, or neither, but no evidence is advanced in the study to support the conjecture that these are inherent individual differences related to the students' cognitive structures.
It is possible, however, to support an alternative conjecture about the
source of the observed types of approach to problem solving. As part of
the present pilot study, the students were also interviewed about their
study habits. Interviews were open-ended, using questions such as "could
you tell me something about how you approach your work?", and these were
followed up with requests for clarification, examples, or elaboration.
Analysis of these protocols also revealed some characteristic types of
study methods. One might be classified as 'visualising the topic':

**Peter:**
"I have to look at things in a lot of different ways. You
have to get a picture of things, a sort of model. I'd ask
myself questions about it, and have to find new ways of looking
at it. I like to be original and find something new out."

Three students described a highly formula-oriented approach to learning:

**John:**
"I go through all the notes and do a key facts appraisal ... 
usually subject headings or sub-headings. If I'm not sure of
it, I might put down a short explanation or key words ... 
I always put down equations or laws."

**Alan:**
"I just revise parrot fashion - write the formula down, turn
over the page and try again until I get it right, to memorise it."

**Rod:**
"What I was aiming to do was, rather than remember everything,
I would try to remember a pattern, and work through that in the exam ... I learnt the notes almost parrot fashion ... Notes on
my lecture notes are circuit diagrams, equations, the important
points."

The remaining three students described approaches to learning that relied
more on reasoning:

**Paul:**
"Doing derivations of different problems is most important ... 
doing problems and learning certain techniques ... I never
learn by heart. I think I subconsciously read and think about
how the steps follow on."

**Stephen:**
"You have to be able to follow the logic ... Understanding it
means it makes sense, it is reasonable this should happen."

**Richard:**
"I think about it and understand why it's so, why it's that way.
I have to recall some information, think about other courses,
other notes."
In these examples, the students were talking about their overall approach to learning their subject, rather than a specific subject such as physics. To some extent these interpretations of different types of study method correspond to the type of problem solving methods used by the students, as is shown in Table 4.2.

### Table 4.2.

<table>
<thead>
<tr>
<th>STUDENT</th>
<th>STUDY METHOD</th>
<th>PROBLEM SOLVING</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PROBLEM X</td>
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<td></td>
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<td>|</td>
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<tr>
<td>PETER</td>
<td>V/R</td>
<td>V/R</td>
</tr>
<tr>
<td>JOHN</td>
<td>F</td>
<td>F</td>
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<tr>
<td>ALAN</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>PAUL</td>
<td>R</td>
<td>F</td>
</tr>
<tr>
<td>STEPHEN</td>
<td>R</td>
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</tr>
<tr>
<td>RICHARD</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>ROD</td>
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</tr>
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</table>

V = visualising the topic.
F = formula-oriented approach.
R = reasoning approach.
I = intuitive.
A = analytic.

The results in the table do not give a clear-cut correspondence between study method and problemsolving method, they are merely suggestive of a possible relationship. The circumstances of the study did not permit the investigation of study methods for a Physics course in particular, and this would have been preferable. The important point is, however, that the styles of thinking found
in these protocols, reflect the descriptions students give of their general study methods i.e. a visualising approach, a formula-oriented approach, and a reasoning approach.

This suggests an alternative source of the differences in problem solving method to that suggested by Thorsland and Novak, namely that the difference has its origin in differences in study methods. The conjecture that the source lies in inherent differences in cognitive structures has not been supported in the original study; indeed no attempt was made to do so. In the present study, the evidence does not support the conjecture conclusively, but it is strong enough to suggest that a follow-up study should investigate both problem solving methods and the study methods that are relevant to them. This is quite different from making an assumption of inherent individual differences, although it does not rule out the possibility of their existence.

4.4. The work of Marton

4.4.1. The Original Experiments

Marton's work on student learning begins with a basic assumption that distinguishes it from most other research studies on student learning: that learning should be studied in relation to the content of what is learned and should not be studied in general. His first studies investigated the relationship between the process and the outcome of learning in both experimental and 'normal' situations. The results of these studies produced an important measure of individual differences in the learning process: some students adopted a 'deep-level' approach, "they concentrated on what the discourse was about"; others adopted a 'surface-level' approach, they "concentrated on surface aspects of the situations: on the discourse itself, on subsequent achievement requirements and so on" (Marton 1975). The method adopted by the
students was shown to result in different levels of the outcome of learning for these students, as measured in tests. All experiments were done with students of higher education, and since the difference revealed was shown to have a significant effect on their general academic performance, it was important that the present study should attempt a replication of individual differences identified.

In one experiment, Marton gave students a text on economics which they were to read and were later told to summarise. The students were then interviewed about how they had experienced the process of learning. It was these introspective accounts that led to the categorisation of 'deep' and 'surface' approaches as in the following examples:

Deep level

"thought about the point of it"

"got a grasp of what it was about"

"tried to get at the conclusions"

"got a clear impression of what it meant".

Surface level

"I didn't remember what I read because I was just thinking of hurrying on"

"I didn't think about what I was reading"

"The whole time I was thinking 'now I must remember this' "

In addition to describing their aims, the students also described the way they set about the task, and here Marton shows that deep level approaches are characterised by "active" methods:

"... made connections between various points ..."

"... went back to find the connections ..."

"... drew conclusions from the tables ..."

"... thought over the logic of the argument ..."

whereas the surface level approach was associated with more "passive" methods:
In the same experiment, Marton showed that differential approaches to learning resulted in differential outcomes: students who adopted the deep-level approach were more able to answer questions on the text than those who adopted the surface level approach. The importance of this study is that it has revealed an individual difference that seems to be reliably identifiable in both the process and the outcome of learning.

4.4.2. The Replication

In the present pilot study, the aim was to investigate the extent to which established individual differences could be replicated. It was therefore the first part of the above experiment that was repeated.

The seven students were given as a text an article by Bertrand Russell ("Can a scientific society be stable?"), in which he argues that a scientific society is not stable, and adduces a number of reasons for this. The connections made between, for example, science, population increase and instability, are moderately complex, and Russell discusses several reasons, so that there is a certain amount of information overload. The article was chosen, therefore, because the content was not too foreign to these students and yet was unfamiliar to all of them, and the complexity of the argument was sufficient to allow any differences in learning strategy to be revealed.* The students were asked to read the article (no time limit was set, but none took longer than 25 minutes) and were told that they would be asked to summarise it. Once they

* If the argument is very simply stated, deep and surface approaches will coincide in outcome. If the argument is complex enough to extend over the whole article, deep level processing is necessary to put the various parts of it together. In this case surface level processing would result in, at most, a list of unconnected points in the argument.
The students' introspective accounts of their approach to the task were very similar in character to those quoted by Marton, and may also be divided into either 'deep' or 'surface' level approaches, as in the following examples:

Deep level approach

Alan: "I was trying to remember the main points he was arguing. I tried to find out first what it's about from the introduction, and then went on to his reasons, which was what I was looking for, relating it to his title".

Stephen: "I tried to understand his argument, see where it's leading, see if it makes sense".

Richard: "I read through trying to get an idea of what he wants to prove or suggest, and how he's going to go about it".

Only two of the students used a surface level approach.

Surface level

Paul: "I didn't read it deeply ... I tend when I'm reading to forget what went before. I take it in at the time, but if nothing really strikes me I forget it".

Rod: "I just read straight through ... I found I would think about it and carry on reading and find I'd have read the last few sentences again because I hadn't been concentrating on it ... some bits go in easily, others don't".

These 'surface' level students also exhibit the kind of passive approach that Marton refers to in comments like "if nothing really strikes me", "some bits go in easily". In comparison with the student comments quoted by Marton, the comments quoted here are sufficiently similar to support the existence of the 'deep/surface' level dichotomy.

The students' summaries of the text also revealed differences in level of outcome, as they did in Marton's study. The major point being made by the article was to argue the relationship between the progress of science, and the social factors that could lead to instability. Students who said they were using a deep level approach talked about the relationship:
... because science is progressing and we can support large populations, the population growth will overtake scientific growth ..." John

"... we are using all our resources and not worrying about where they will come from ... he seems to blame it all on science. He seems to think that the way the world's going downhill we can't go on". Alan

"He's basically advocating that in its present form the scientific society is unstable unless there is drastic population control and control of resources ..." Stephen

Students describing a surface level approach in interviews, however, did not mention any relationship in their summaries but simply referred to the supposition of instability:

"It was about whether a scientific society could be stable ..." Paul.

"It's basically about the ethics of science and how he doesn't reckon we will survive much longer unless man's wisdom increases." Rod.

The dichotomy is supported, therefore, but its importance will depend upon the extent to which it is found in the students' 'normal' work, and it was this point that provided the focus of a further study by Marton.

To find the counterpart of levels of processing within the students' everyday academic work, Marton interviewed students on how they set about their studies. Levels of outcome were assessed using the usual assessment methods. Once again, the dichotomy was revealed, and once again deep level processing correlated with quantitatively better examination results.

In the pilot study, students were interviewed about their study methods (as reported in Section 4.3.2.). To use comments about general approaches to study as evidence of the approach to any particular topic (such as those assessed in examinations), makes an important assumption. It assumes that the individual differences found in experimental situations are characteristic of the individual outside that situation. However, in interviewing students about
their study methods it seemed that the methods used were not always the same for each student. These results will be reported in more detail in the next section. The important point here is that students' general comments about their study methods do not necessarily provide an account of how they normally work on a particular topic. Comparison of examination results on particular topics with general study methods therefore makes the assumption that individual differences are immutable, without testing it.

For this reason, the more general interviews in the pilot study were not used to test the existence of the deep/surface dichotomy in normal studies. Instead, the first experiment was repeated, but using, as text, some reading the student was doing as part of his work at that time. This meant that it was possible to relate the method used to the particular topic concerned.

4.4.3. The Extension of Marton's Work

The students were asked to bring their own reading matter, the only stipulation being that it should be something they would be reading anyway as part of their work, and that it should take them about 20 minutes to read. Once again they were asked to read at their own pace, and told they would be asked to summarise it when they had finished. They were then interviewed about their approach to the task, and about the context within which this particular piece of work was being done.

Once again, the students used similar descriptions of their approach which may be readily interpreted as either deep or surface level approaches. However the two students who now use the surface approach are not the same two who used it in the first experiment. This is one counter to the assumption of immutable differences. Another is the possible source of the difference in levels of processing. The students were interviewed about the context within which they were doing the reading, and their comments here relate to their
reasons for doing the work, and what they are aiming to do. Their comments also exhibit characteristic differences: the reasons may be connected with working for interest, when the aim is to understand; or they may be connected with working for marks where the aim is to reproduce. These different types of comment are related to the two different levels of processing. The following quotes illustrate these differences, where the first five describe what may be called 'intrinsic' reasons and aims, and the last two describe 'extrinsic' reasons and aims. In each quote reasons and aims are differentiated from methods of approach by different types of underlining.*

'Deep' level processing; 'intrinsic' reasons and aims

Peter:

"I want to understand the theory of what I'm doing to do a good write-up and get the results. It's difficult because it's three-dimensional and it's hard to picture what's going on. I was trying to work out what's happening to this point moving on a surface. I think it's better if you work it out, you have to deduce what you need then you always remember it. I couldn't understand it the first time - I just read it to get some idea of what it's about, then went back to get a better idea the second time. I think what I'm trying to do is picture what's going on and see the model they're using".

Paul:

"I have to use this for my project. I want to do as much of the steps as I can to understand what's going on - it seems a bit daft just to copy it out. Changing the notation helps to understand it. I have to check it with another book because it misses out some steps and this is for a different system. First I read the introduction to see what they had to say about it, why it gives a reasonable approximation, and what it neglects, because you have to realise the limitations of the method. I worked through in steps within sections. I knew to a certain extent what was coming. Some

* Reasons; .................................................................
* Aims; .................................................................
* Method of approach; ........................................
bits I had to concentrate on - had to put in values and then you can see that one step does follow from another. I am trying to understand it. It's not like learning for an exam."

Stephen:

"There's some stuff later in this book I've flipped through before, it looks quite useful, but to understand that you need this to be able to do it. It's something that interests me in chemistry that we've only covered a bit in lectures. If it's only short

bits I go through and go back and read again until I understand it, particularly the important bits. The bits I concentrated on were bits essential for the next section or bits I was interested in.

I was going through it fairly quickly. This is interesting, but I'm definitely out of my depth the first time, next time I read through again a bit more will stick. I'm thinking about the stuff further on. It assumes you understand this and uses the results, so you have to go through this first."

Richard:

"It's something I'm reading for interest. I think it will be useful. You continue your education after exams. You have to stay in touch with your field. I read slowly. I read it as slow and as many times as is necessary. I think I read this line three times to get it clearly in my mind what he's going to talk about. A lot of it I read twice to organise in my head the interplay between it all, the significance of it."

Rod:

"I was trying to find out what's behind it, what the point of it is, and then how it works, because I've got to build something a bit simpler than this but using the same principle. First I read through to see which bits would be relevant to what I needed to know, then it started getting a bit complicated and I went back and made notes on the main points till then so I had an understanding of the basics and could go on to the more complicated stuff on that basis. I had the circuit in mind and tentatively thought about how I'd apply that principle to my circuit. I missed out a bit that was irrelevant - it was a bit I didn't understand, but I realised I didn't need it."
All these students are aiming at something very specific - at finding out what's behind it, at understanding it, at picturing the model, and these aims are reflected in the characteristically 'active' descriptions of the methods they use - deducing what you need, checking it with another book, thinking about how to apply a principle. The reasons given for doing the work are either for interest or for a project the student wants to do well. Thus the student is doing the work for its own sake, either for interest in it, or for its application. This contrasts with the next two 'surface' level processors whose orientation* is purely extrinsic - for the sake of the external rewards of examination marks rather than anything to do with the subject matter itself.

'Surface' level processing; 'extrinsic' reasons and aims

John:

"This is almost a must for an exam question. I'm not exactly sure how it works, there's something here, I'm not sure about this. It was a problem that occurred to me, so I had a quick think, but I decided it wasn't easy, so I went on. I just have to hope it doesn't come up, although it's pretty basic. But we don't need such details for the exams. We only have to know the basic principles. There would be some point in finding out what it meant if it was likely to come up, but it's not. I started reading - I tried to divide it up into sections and worked through doing it by paragraphs and made notes under separate headings, making notes of the key facts. Just trying to memorise the key facts and the formulae. I make notes to get familiar with the material - it's now embedded in my mind as well as possible, but I can never remember every detail."

Alan:

"The main thing is to be able to explain it in the exam. I just try to reason it out, and explain how it works. If you can explain how it works it makes it easier to remember. I read it through once then again, and over again until I felt I knew what their explanations mean. I'm still not too happy about it, but I take their word..."

* Throughout the thesis, I have used the word 'orientation' instead of 'motivation' to avoid the many other associations the latter has. 'Orientation' is used to mean, specifically, 'the kinds of factors the student is conscious of when he is doing a piece of work'. 
to learn it parrot fashion. The first part was just general introduction, I went through that quickly. I read through how they adjusted it and related it to the diagram - that's the main thing if you can produce that in the exam."

In both these extracts the reasons are clearly extrinsic - to reproduce the material in an exam. The aims are both typical surface level aims: to learn it parrot fashion, to memorise the key facts and formulae. The methods described are not pure surface level approaches as there is mention of more active methods such as "reason it out", "had a quick think", but in both cases these methods are abandoned, apparently because they are not necessary to achieve the surface level aims.

In this part of the study it was not possible to compare methods with outcomes because of the variation in the content of the reading. The congruence of level of processing with level of outcome, found by Marton, had been replicated in the first experiment. The priority now was to investigate relationships between parameters of particular learning situations even if this meant abandoning the investigation of the relationship between method and outcome, which was less problematic.

It is therefore important to consider the learning situation as a whole; individual quotes which correspond to the defined differences should not be taken out of context, but should be related to the student's perceptions about all aspects of learning a particular topic. The characteristic differences Marton found in levels of processing (or what the student is aiming for) and in approaches (i.e. active and passive methods) may also be extended to the reasons for doing the work. From the data quoted here, it is the relationship between these three descriptors (aims, reasons and methods) that remains constant, rather than the characteristics of each student. The fact that four
of the students used different approaches on the two experiments suggests that deep and surface level processing is not necessarily a characteristic of the individual. Instead it could be construed as a characteristic of the individual's response to the situation; insofar as he has intrinsic reasons for doing a piece of work, he may be expected to use deep level processing and active methods of approach.

The data collected from these two experiments in the pilot study thus suggests two main conclusions: that it is possible to identify characteristic differences in approaches to reading, but that these should not necessarily be seen as individual differences. Indeed the constant relationship between the different parts of each student's description of a piece of work suggests that the source of the difference may lie in the student's perception of the context within which he is doing the work, rather than in some inherent characteristic. Any follow-up to this work, therefore, should investigate the learning task in its entirety, taking into account the student's reasons and aims, and, where possible, the source of his reasons and aims. It is not sufficient to concentrate on the relationship between method and outcome.

4.5. The work of Parlett

The final part of the pilot study to be discussed is the session comprising an open-ended interview with each student on his general approach to academic work. This was not, by its nature a strict replication, but was based on the work of Parlett in the field of educational evaluation. In a wide range of studies, Parlett has used open-ended interviews with students and teachers, the results of which have in each case emphasised the importance of the context of learning. Parlett has summarised these results in the following conclusion:
"Teaching and learning involve far more than 'transmission and reception of knowledge' that can be elucidated by attending to 'inputs' and 'educational products' - students/pupils do not respond merely to presented content and to tasks assigned but, rather, they adapt to and work within a local teaching and learning milieu which embodies and transmits conventions, beliefs and models of reality that are internalised, govern the total response to presented academic tasks, and influence profoundly the processes of socialisation and intellectual development."

(Parlett 1976)

The aim of this part of the pilot study, therefore, was to investigate whether students do report adaptations to the teaching and learning milieu, and if so, in what way it governs their response to academic tasks. This study was not done as part of an evaluation, so that students were not all working within the same teaching and learning milieu. The pilot study was a series of case studies on individual students, using the method of open-ended interviews to elicit the student's perceptions of their response to the context within which they were working.

At the beginning of the session, students were told that they would be interviewed for about half an hour on their approach to their academic work. They were told that the aim of the pilot study was to "try to identify and describe the ways students go about their academic work". All questions were strictly open-ended and began with a preliminary question "How have things been going this year?" Occasionally questions introduced a new topic, for example, "What about revision?", but most were requests for clarification, elaboration, or examples. All interviews were recorded and transcribed verbatim.

The open format of the interviews allowed students to range widely over their feelings about, and attitudes to the educational system they were experiencing. The interviews were essentially exploratory, following the student's direction rather than any particular research idea. The aim was, in part, to generate ideas for further investigation rather than to derive a structured summary of all the interview data insofar as part of the aim was to replicate Parlett's
conclusion that students adapt to their milieu, points that related to this were followed up with requests for elaboration, and in this sense directed the orientation of the students' comments. They were never asked specific questions on this, however.

The analysis of this interview data was used partly to generate a more structured interview for follow up studies*. Parlett's work suggested that the students' perception of their learning milieu would influence their working methods, so the analysis was also done by extracting those quotes from each student that refer to reasons for their adoption of particular working methods. Since it is possible to show both that the students relate their working methods to various aspects of the context of their work, and that some use different methods according to different circumstances, the students will be discussed individually.

The first student discussed the importance of his interest in the subject in determining the way he works:

Peter: "There were some subjects I didn't bother with, but the ones I was interested in I had to do everything.... I have to look at things in a lot of different ways. You have to get a picture of things, a sort of model. I'd ask myself questions about it and have to find a new way of looking at it. I like to be original and find something new out ... the only way I can learn something is if I really want to know about it."

When motivated by interest in the subject, this student described working methods that are highly active, and correspond well to Marton's deep level processing. As circumstances changed, however, his approach also changed:

Peter: "In the first year I was very keen, and wanted to understand everything, and look further ... but this year I haven't bothered, just learned how to do the problems. I think it was because of the industrial year, because when you work for a year you feel you can do the job anyway. There I learnt FORTRAN in an afternoon, but we took 10 lectures to learn ALGOL."

A further reason for the loss of interest emerged when the student described his more recent working methods:

* See Chapter 3, Section 3.4.1.1.
Peter: "I've lost interest in the past year, I just do it mechanically ... There was one problem that was exactly the same but I couldn't do it in the exam. It was a mechanical proof. I made notes, copied it down. I seemed to understand the method, but not the theory behind it."

I: "You described your method of working now as mechanical - could you elaborate?"

Peter: "I think it's not necessarily just me, it's the attitude of lecturers, people in the department. I really wanted to learn about and understand things, whereas they wanted to make you an engineer, to be able to do things and solve problems. I find it hard to operate that way, I find it easier just to understand it. You're pressurised into doing it the wrong way..."

This student describes two quite different ways of working, where the more active approach is associated with interest in the subject, and the more mechanical approach is developed in response to the teaching strategy he encounters.

The second student also describes several ways in which the teaching and assessment methods in his department led him to work in a more 'mechanical' way:

John: "Exams are very memory-oriented, they don't test intelligence ... my thinking is oriented towards exams, exams are what's important. Being able to understand a subject is not so important for the exam... For revision I go through all notes and do a key facts appraisal, I just write them down, it helps to learn them ... I try to memorise them."

"Labs. have been too easy, ... they've been very mechanical, you don't need to do much preparation ... It's not very stimulating. What changed was that you began to realise what they were looking for, you found out that although you did lots of preparation and got interested all they did was count how many pages of preparation you did ... In the second year I knew what they were looking for and just gave it to them ... Once I'd learnt the game it wasn't interesting ... for example this year I'd write out pages from a book then copy out the method and every time they gave me extra marks for writing down the method. Incredible."

In both the cases quoted here, the student bases his working method precisely on what the assessment system demands, in the second case changing his method as his perception of the system changed. When circumstances are different, for example the assessment system demands something other than memory, his methods change:
John: "Exams are very memory oriented, they don't test intelligence. It's the same for all subjects except electronics which is more concepts, not very problem-oriented. I read through carefully, it makes you think a lot more because it's concept-oriented ... I don't understand it so easily so I have to think about it more ... I like physical electronics, because, although parrot fashion learning gets you through exams, it's very boring. And you get more satisfaction out of really understanding it."

I: "How do you go about understanding it?"

John: "To understand it, I read it, reread it, thought about it, tried to visualise what's happening. I see electrons going across a junction. If it's very difficult, I draw diagrams. Not diagrams from books, my own, when I'm trying to understand it; only book diagrams when I'm revising."

Here the student describes working methods that are highly active when the context is a conceptual subject that requires understanding rather than memory or practice with problems. This student is also conscious, therefore, of adapting his methods according to his perception of the teaching and assessment aspects of the context.

The third student describes a predominantly mechanical approach to his work, oriented towards what is needed in the exams:

Alan: "I haven't really done much work ... I wait till exams and then do last minute revision ... I'm not sure whether I like this subject ... For revision ... I go through the notes and always do examples ... If you make very brief notes, there are too many just re-writing lecture notes, but just write revision notes, subtitles and formulae, then go through those later ... Most examples are straightforward. Sometimes you have to derive a formula, then put numbers in. I memorise formulae parrot fashion... For deriving you can do it roughly, not rigorously, you just fiddle the numbers. Just revise it parrot fashion.

Again, lack of interest, and the perception of what is necessary for the exams determined the working methods of this student. However, there were occasions when the teaching and assessment encouraged a more active approach:

Alan: "Some practicals are very good, you can relate your ideas to the actual machines ... Practicals are useful because they make me work the way they design them. You have to do some preparation on what you do in the lab. so you have to try and understand it... Sometimes they give you hints on how to do it and you go away and check the theory and design your method, and find out what your conclusion should be."
The working methods described here are still oriented towards coursework marks, but the teaching and assessment system provides the opportunity and the incentive for this student to use more active methods than in the different circumstances described above.

The remaining four students described only one basic kind of working method. Three described only 'deep' level approaches and related these to 'intrinsic' orientation:

Paul:  "To revise, I read it and derive the formulae. I never fix in my mind a whole page ... I usually say to myself then you do that, then you do that etc. and then if it comes up in the exam you have to work out every step as you go. It's an impossible task to learn everything off by heart. I make a point of being able to understand it."

Stephen: "In understanding a subject, in the lecture to start with, I just copy notes off the board, understand some of it, then read through notes, use text books ... go back and read it a few times, until it actually falls into place - makes sense, is reasonable this should happen, doesn't jar with other things I already know ... I have to be able to follow the logic behind it, that helps."

Richard: "I'm not saying I know it all, but if I need it, I can understand it."

I: "How do you get to understand it?"

Richard: "First you read it, then try to get it organised, try to visualise it ... The first time you understand the general argument, then when you go over it you begin to remember the specifics ... just read and follow the logic."

Whereas these students tend to relate deep-level approaches to their aim to understand, and did not refer to the influence of the context of learning on their method, the final student, who only described a surface level approach, was influenced in this approach by the context in the negative sense that the course did not match his interest;
Rod: "I thought it would be mostly practical, building circuits, and thought it would be mainly electronics. But I discovered it was mainly maths and mainly learning, and boring things like machines and power ... I got to the stage where I was just doing the work I had to ... I kept lecture notes up, not being interested and not concentrating, just writing down what was on the board ... The last week of revision was panic revising. I found I could memorise quite a lot, circuit diagrams and so on. Just look at it, remember parrot fashion, then try and write it down and check it."

The major influence of the teaching context here was to invalidate the student's intrinsic orientation, his interest in electronics, leaving avoidance of failure as the only incentive to work, which in turn produced strictly 'surface' level approaches to revision. The same student (Rod) has already been quoted (4.4.3.) in another session, however, as using a 'deep' level approach on the more practical project which he was interested in doing. It was still possible, therefore, for favourable contextual conditions to elicit a more active approach in this student's work.

One conclusion that emerges from these interviews is that all the students relate their working methods to their aims. For the students who are interested mainly in their subject and want to understand it, there are very few references to the influence of teaching or assessment on their approach to work. Of the other four students, three are conscious of changing their working methods according to their perception of the teaching and assessment methods they encounter*.

A second conclusion that may be drawn concerns the importance of the nature of the student's orientation in determining the nature of his response to the context of learning. The 'intrinsically' oriented students (Paul, Stephen,

* The fourth student (Rod) shows evidence of similar changes (see above Section 4.4.5), although not consciously.
appear to be less concerned with the nature of exam. questions, or the vagaries of the teaching they have. The two students (Peter and Paul) whose intrinsic orientation was thwarted by the nature of the course resorted to almost purely mechanical methods. The two students (John and Alan) whose 'extrinsic' orientation was related mainly to assessment, changed their methods according to the demands of the assessment system. To state the extreme form of the conclusion: a student who is 'intrinsically' oriented will be less affected by contextual conditions as long as they do not positively interfere with his aims; a student who is 'extrinsically' oriented will adapt his working methods according to his perception of the contextual conditions.

The analysis of this data cannot support definite conclusions, because the interviews only set out to be exploratory. They were therefore capable of generating hypotheses about the nature of the relationships students were conscious of within their teaching and learning. In this sense the interviews replicated Parlett's findings that students are conscious of adapting to contextual conditions. This part of the pilot study therefore suggested that follow-up studies should continue to investigate the role of the student's orientation to his work, and how this is determined by his response to the context.

4.6. Implications

Two of the studies on individual differences (Thorsland's and Marton's) made the basic assumption that students are categorisable according to the working methods they consistently use. Bruner's study is ambiguous as to whether the students are consistent or adaptable. Parlett's conclusion is that students are adaptable.
In each of the replication studies it has been found that students are not consistent in their adoption of working methods. However it has been shown that it is possible to relate their inconsistencies to the students' perceptions of their reasons and aims in doing a particular piece of work.

The conclusion is, therefore, that in studying student learning, the focus should be upon the relationship between various aspects of the learning situation. Students do not divide easily into one type or another - both Thorsland and Novak, and Bruner report students who exhibit more than one strategy. It has been demonstrated that differences in working methods occur, but they do not seem to be inherent individual differences. So how do they arise? It would be an arid policy to ignore the question and simply provide a statistical description of the student population in terms of different basic types. A possible source of the occurrence of different working methods has been suggested by the outcomes of the pilot study. This was pursued in the main study.

Based on the results of this pilot study, follow-up studies were designed on the following lines:
(a) A series of studies should be made of students working on a variety of particular, everyday academic tasks.
(b) Full information should be obtained about each of these learning situations, including the student's reasons, aims, methods, and perceptions about relevant teaching and assessment.
(c) These reports should be analysed in terms of relationships between the various aspects studied, in particular looking for consistency in the relationships.
(d) General open-ended interviews should be continued to assess students' overall orientation, and its relationship to their modes of working.
The replication studies have been successful in supporting the existence of different modes of working, and these are valuable concepts which can be utilised in the analysis of data. The basic assumption of consistent individual differences between students will not be pursued however as this has not stood up to replication. Instead, consistency will be sought in the underlying relationships, as a way of simplifying the complexity of the problem of student learning.
5.1. **Introduction**

The main outcome of the pilot study, as described in Chapter 4, was the suggestion that students do exhibit characteristic learning styles, such as those described by Marton, but that these depend not only upon the inherent characteristics of the individual, but also upon the individual's response to external conditions.

The follow-up study to this, which constitutes the main part of the research work, was designed to investigate this outcome more fully. Some attempt had been made in the pilot study to relate individual differences to the students' real academic work, and met with sufficient success to justify more investigations of this type. In the main study, the emphasis is not on replication of previous research findings, therefore, but on the extension of these into normal academic work - the aim is to establish how far the different learning styles and attitudes already identified still apply.

The research methods developed for this part of the study have been described in detail in Chapter 3. The analysis of the transcripts of students' accounts of their work has been based on the ideas of Marton, Pask and Perry, and this chapter will describe these results, accordingly in three sections.

5.2. **Deep and Surface level processing**

5.2.1. **Definition of the Dichotomy**

Marton and his colleagues have characterised deep and surface level processing in terms of a collection of descriptions of the student's approach to a
learning task. The transcript of the student's account of his approach can then be analysed in terms of these descriptions to determine the extent to which he is a deep or surface level processor. The descriptions Marton uses for this analysis are as follows:

"Deep level approach."

1. **Subject focuses attention on the INTENTION OF THE ARTICLE (AUTHOR).**
   e.g. wanted to find out the aim of the article.

2. **Subject ACTIVELY TRIES TO INTEGRATE WHAT HE WAS READING WITH PREVIOUS PARTS.**
   e.g. went back in order to see the connection.

3. **Subject TRIED TO USE HIS OWN ABILITY TO MAKE A LOGICAL CONSTRUCTION.**
   e.g. thought about the logic of the arguments.

4. **Subject THOUGHT ABOUT THE FUNCTIONAL ROLE OF THE DIFFERENT PARTS.**
   e.g. thought about how the whole thing was constructed.

"Surface level approach."

1. **THE ATTENTION WAS FOCUSED UPON THE TIME FACTOR INSTEAD OF UPON THE ACTUAL TASK.**
   e.g. it was an awkward feeling of being forced to get through it in time.

2. **THE ATTENTION WAS FORCED UPON THE DEMAND TO PERFORM INSTEAD OF UPON THE ACTUAL TASK.**
   e.g. concentrated upon having to recall.

3. **THE ATTENTION WAS FOCUSED UPON MEMORISING INSTEAD OF UPON THE ACTUAL TASK.**
   e.g. concentrated upon remembering.

4. **Subject DEFINES LEARNING AS BEING EQUIVALENT TO MEMORISING.**
   e.g. you have to read it several times if you are to remember.

5. **SUBJECT CONFRONTS THE TEXT PASSIVELY AND TREATS IT AS AN ISOLATED PHENOMENON.**
   e.g. read without thinking.
6. Subject keeps his reading to the surface of the text (without any relation to the meaning).

   e.g. thought about the conclusion but not about how they had reached it." *

These definitions are designed to describe the differences found in students' learning styles but they do not relate to a theoretical account of their origin. Marton's early experimental work showed that there was a strong relationship between the level of processing and the level of outcome, but it did not posit the source of the students' approach. It was not clear whether the deep/surface dichotomy described an inherent difference, an acquired difference, or whether it described a variable response contingent upon the situation. Some of Marton's colleagues have since studied the relationship between students' characteristic styles in several different situations, and have found them to be generally consistent.** The theoretical basis of the dichotomy, however, simply relates method to outcome, and does not specify its underlying nature. Because it is a description of observed learning styles, there is no theoretical requirement of a consistent difference between individuals. It may be found empirically, but the current position outlined by Marton states that different learning styles exist and affect learning outcome. Whether the dichotomy does discriminate between individuals is yet to be determined.

As descriptions of students' approaches to learning, Marton has shown that the above definitions can be successfully applied under experimental conditions. The pilot study described in Chapter 4, section 4.4.3. indicated that they could also be applied to normal academic work, and this part of the study tests

* These definitions are taken from a private communication.

** This will be discussed later, see Section 5.2.3.
that finding further with a larger group of students. The above descriptions are sufficiently well-defined to allow an unambiguous analysis of students' accounts of their approach, but are also sufficiently general to be applicable to learning tasks other than those used in the experimental situation.

5.2.2. **Application of the dichotomy to students' normal work**

In the present study, students were asked to bring with them work they were doing as part of their course. They were interviewed about their approach to that particular piece of work, and it is these protocols that provide the data for analysis.

Since the topics concerned were not, and could not be chosen by the researcher, they covered a number of different types of learning task in several different subject areas. The learning tasks can, however, be subsumed under the two general categories, problem solving and reading. Reading tasks, being similar to those described by Marton, could certainly be expected to exhibit similar results. Problem solving is a quite different kind of task, but can nevertheless admit the same descriptions since Marton's explanatory examples give the descriptions a wide scope of application. For example, 'focusing attention on the intention of the article' is characterised by 'wanting to find out the aim, the point, the conclusion, what it was all about'. In problem solving this is paralleled by thinking not just about what is given, but also about what is needed, keeping the end-point in mind throughout the solution process.

Similarly, it is important in problem solving to integrate the different parts of the problem, to make logical constructions and to structure the solution. These descriptions are equivalent to many of the ideas in Polya's 'heuristic reasoning'; "understand the problem as a whole", "consider the principle parts of the problem", "decompose and recombine the elements of the problem", "devise a plan", "check and examine the solution". (Polya, 1957). Thus in problem solving, as in reading, it is important for the student to focus his attention...
When the deep level approach is not found in a student's account of problem solving, we can expect surface level characteristics to appear, as they do in reading tasks. In the context of problem solving the surface level definitions must be reinterpreted to some extent, as problem solving is necessarily an active rather than a passive task, unlike reading. Some of the surface level definitions are inappropriate, therefore, since if the problem is attempted at all, it is not confronted entirely passively. It is possible, however, for the student to treat the task as a mechanical process of remembering solution techniques or to approach the problem unthinkingly by, for example, trial and error.

Taking these points into consideration, Marton's original definitions can be generalised, without loss of meaning, to be applicable to both reading and problem solving tasks. The surface level characteristics have been reduced to four by excluding (1), since no time factor was involved in the present study, by combining (2), (3) and (4) as S2, by making (5) into S3, and by generalising (6) to become S1. This produces more generally applicable characteristics: A third of the students' protocols were analysed, using these definitions, by one other judge as well as myself. Altogether three judges were involved.

Deep level processing

D1. Focusses attention on the content as a whole.
D2. Tries to see the connection between different parts.
D3. Thinks about the logical connections involved.
D4. Thinks about the structure of the whole, the functional relations.

* That an entirely formulae-oriented approach is possible was shown in the pilot study, section 4.3.2.
S1. Focusses only on the elements of the content.

S2. Sees the task primarily as a memory task.

S3. Approaches the task unthinkingly.

With the deep/surface dichotomy defined in terms of these characteristics of approach, it is now possible to analyse the students’ accounts to determine the extent to which the dichotomy is exhibited.

The following sample quotes are identified by student and task: R for reading, P for problem solving. They illustrate the range of comments that can be classified under each different definition.

D1. Focusses attention on the content as a whole

"I check what is the main point" Joe (R)

"I look to see what he wants to talk about" Joe (R)

"I started reading at the end to get an overall picture of what he was saying" Isaac (R)

"You have to think about it and understand it first" Chris (P)

"I started by ... deciding what I needed to prove. I tried to set up in my mind how I was going to do it" Tim (P)

"You do it by putting things in boxes, forget what's inside them and look at the whole picture" Ian (P)

D2. Tries to see the connection between different parts

"I looked at an example and referred back to the diagram ... and remembered the reasons and assumptions and how they were derived" Joe (R)

"The diagrams are good because they simplify the story ... the mind makes a comparison immediately" Joe (R)

"I have to go through the flow chart to visualise the problem and follow it through" Bill (P)

"I thought about the original outline and looked for facts to fit it" Isaac (R)
"You're told so much, you need to find some kind of relationship" Ian (P)

"I had to relate the information in the book to my results" Charlotte (R)

"Looking at the system I was thinking out what is actually happening, relating numbers to features" Robert (P)

"It fell out into two problems straight away. I tried to work towards a pattern until I found something that might work" Tim (P)

D3. Thinks about the logical connections involved

"I look at how it changes from line to line" Joe (R)

"I worked out why one line could be converted into the next ... I worked through the steps in between, then I saw where it came from" Joe (R)

"I work through trying to rationalise it, working through the logic of the program" Bill (P)

"I check through to see where it's wrong, following it through" Isaac (P)

"I had to reason through what was actually happening in the beam, where it was most likely to break, giving reasons why it was likely or not" James (P)

"I try to work through logically, putting in diagrams helps you think clearly and follow through step by step" Chris (P)

"It has to be judgement, what to assume and what to guess, but you have to justify your assumptions" Ian (P)

D4. Thinks about the structure of the whole

"First I draw a block diagram ... then took notes to get more ideas and added these to the block diagram" Isaac (R)

"You break down the structure of the problem into small bits" James (P)

"First I had to decide on the criteria of how to approach it, then drew a flow diagram" Chris (P)

"Looking at the system, ... I was putting it all together" Robert (P)

"It's quite reasonable to start at the end, though on some occasions it could lead you falsely" Tim (P)

"You tend to see what you're going to aim for at each stage, and you see how to split it up" Tim (P)
"You have to make a basic assumption to work through, then you work backwards to check your input, then forwards again" Ian (P)

S1. Focusses only on the elements of the content

"I read through making notes on things worth noting. I started off with the definitions" Susan (R)

"I condense it, getting the key ideas down" Susan (R)

"I started by writing down equations, but you should start by thinking of what you need" James (P)

"I'm just looking for an equation ... you skip what you don't need" Chris (R)

"I knew how I'd do it from looking at the question, it practically tells you what equation to use" Chris (P)

"You have to set it out concisely and put in a few pictures" Charlotte (P)

"I looked up the formulae and made the calculations from those" Robert (P)

S2. Sees the task primarily as a memory task

"I know some shapes by heart, but I have to look up others" Bill (P)

"I'm doing a precis, picking out facts I think might be useful" Susan (R)

"I make a precis so that it's like lecture notes, for revision" Susan (R)

"These are general notes. It's an easy way of putting down principles so you can revise it" Ronald (P)

"I tend to write down certain things I rely on myself remembering for the next year or two ... you can remember it that way" Brian (P)

"I can't read something and remember it. The only way I can learn something is to do it. It's all done for us here - it really sticks if I do it" Roy (R)

"The more times you write it out, the better you remember it" Ronald (R)

S3. Approaches the task unthinkingly

"I don't understand this definition ... for now I'll just carry on without it" Susan (R)
"I started too quickly without thinking of the object" James (P)

"You don't need to look at the system, you don't have to interpret it" Chris (P)

"I just copy from last year's notes" Robert (P)

"We don't quite know what's expected ... it's difficult to go through in logical steps, to see the paper as a whole ... it's confusing. I really get myself in a jam" Sean (R)

"I must admit that some of this was guesswork ... we don't seem to have been explained how to use it" George (P)

"The book helped me directly with the problem without having to understand the book, because it explained exactly what you were doing" Ronald (P)

"You can't really go wrong. It's all done on the diagrams for you ... you can go through without thinking about it at all" Ronald (P)

In the analysis of these protocols, agreement between three pairs of judges was 72%, 75% and 85% on the first analysis, increased to unanimous classifications after discussion.* All the judges reported that the analysis was reasonably straightforward.

All these sample quotes illustrate the fact that students use different styles of learning, in both reading and problem solving tasks, and these can be unambiguously classified according to definitions of deep and surface level processing similar to those used by Marton. All 31 students in the follow-up study can be described according to the styles they used on each learning session, where a session refers to a time when the student talked about one particular piece of work. Of the 31 students, 12 were consistent in using deep level processing on every session. The remaining 19 used both styles on different occasions. Rather than categorising students as deep or surface level processors, therefore, it would be preferable to categorise each learning situation as being either deep or surface level. The quotes above are

* Samples of the protocols were also sent to Prof. Marton who reported his agreement with my analysis in the letter reproduced in Appendix 4.
constituent parts of a students' description of a learning situation, but the extracts below are complete* accounts of two situations for one student which belong to different categories. The two extracts demonstrate that one particular style is consistent throughout a particular learning situation.

Deep level processing

"This has to be handed in - it's an operation research exercise, a program to find a minimum point on a curve. First I had to decide on the criteria of how to approach it, then drew a flow diagram, and checked through each stage. You have to think about it and understand it first. I used my knowledge of O.R. design of starting with one point, testing it and then judging the next move. I try to work through logically. Putting in diagrams helps you think clearly and follow through step by step. I chose this problem because it was more applied, more realistic. You can learn how to go about O.R. You get an idea of the different types of problem that exist from reading."  Chris (P)

Surface level processing

"This problem is not to be handed in, but it will be discussed in the lecture because the rest of the course depends on this kind of thing. I knew how I'd do it from looking at it, it practically tells you what equation to use. You just have to bash the numbers out. I knew how to do it before I started so I didn't get anything out of it. There's not really any thinking. You just need to know what you need to solve the problem. I read through the relevant notes, but not much, because you don't need to look at the system. It's really just a case of knowing what's in the notes and choosing which block of notes to use. You don't have to interpret it in terms of the system. It's only when things go wrong, you have to think about it then. In this sort of situation you've just to get through to the answer."  Chris (P)

Both the above extracts are typical in demonstrating that the style adopted is consistent throughout a particular learning situation. In the context of the full account, however, the surface level descriptions take on a slightly different character from that identified by Marton. The actual approach taken is similar - there is a concentration on words, or facts, or formulae, on memorising, and doing things mechanically rather than thinkingly - but in context these descriptions often appear to relate to conscious strategies. The same student above, for example, sees the task in a different way in the two cases. In the second case, he is certainly not thinking deeply about the

* They are not verbatim - repetitions and redundant statements have been omitted.
problem - some of the deep level characteristics are there as they are in the first case. But it is a consciously chosen strategy in the sense that he knows what he needs to do, and in this case it happens to be very little. This is rather different from Marton's identification of the surface level approach with a passive approach to learning.

The same point can be supported by the results from the analysis of other students' protocols. All the students who, on some occasions, exhibit a surface level approach, are nonetheless capable of a deep level approach which they do adopt on a different occasion. These results suggest that the deep/surface level characteristics are not descriptions of the student, since they are not always consistent across different situations. Instead, they are descriptions of the student in a particular context.

5.2.3. Discussion of the results

The analysis presented here supports Marton's discovery of different learning styles, which may be classified as deep and surface levels, and shows that these can be applied to students in different types of normal working situation. But how do the overall results relate to the further work of Marton and his colleagues?

As mentioned before, the theoretical basis of Marton's work does not assume that the differences identified are consistent characteristics of the individual student. In more recent work (Marton et al. 1977) he acknowledges that the differences can reflect the students' perceptions of the task:

"Learning does not take place in a vacuum but in various social contexts. Learning situations are characterised by the demands they make, primarily in the form of exams, grades etc. "Surface-orientation" in learning ... is to a large extent, a product of this situation." (Marton et al, 1977)

Thus the differences are descriptions of the student working in a particular context:
"we may view "surface-orientation" as caused by certain non-desirable conditions in the learning situation (lack of relevance, stress, anxiety etc.)." (Ibid)

The studies on which this work is based, however, do not investigate students working in different situations. Instead they use research strategies similar to those used earlier by Marton which utilise a standard academic text in an experimental situation i.e. divorced from the normal learning context. Later work has related these experimental studies to 'normal work' by interviewing the students about their study habits. But again, these are study habits in general and this has the result of classifying each student as either a deep or a surface level processor. Thus there is no opportunity for these studies to reflect differences within students, even though this possibility is recognised by the researchers. Svenssons' study (1977) showed, for example, that most students adopted the same strategy in both experimental and normal studies and that the deep-level processors tended to be more successful in examinations. The interviews on normal studies, however, assumed, by their general nature, that students would be consistent in their approach - contrary to the recognition that these differences are the product of the learner in context.

The results reported here suggest that some students do adopt different styles in different learning conditions. This conclusion does not conflict with the theoretical standpoint of Marton and his colleagues, and indeed supports it more firmly than they do themselves. This may be because the focus of their work is to relate strategy to outcome, for which their research strategy is appropriate. But this conclusion is an interesting extension of their work into the normal working conditions of students. The next step is to investigate the relationship between the context of learning, and the learning styles adopted by students, and this will be followed up in the next chapter.
5.3. Operation and Comprehension Learning

5.3.1. Definition of the Dichotomy

A second important dichotomy of learning styles is that identified by Pask as operation/comprehension learning. These are defined by Pask as follows:

"Left to their own devices, operation learners pick up rules, methods, and details, but are often unaware of how or why they fit together. They have at most a sparse mental picture of the material and their recall of the way they originally learned is guided by arbitrary number schemes or accidental features of the presentation. On the other hand, if an operation learner is provided with a specific description ... he assimilates procedures and builds concepts for isolated topics. His cognitive repertoire includes accessible or effective procedure building operations"

"Comprehension learners readily pick up an overall picture of the subject matter ... and recognise clearly where information can be obtained. These individuals are able to build descriptions of topics and to describe the relation between topics. Their cognitive repertoire includes effective, though individually distinctive, description building operations." (Pask 1976)

These descriptions are well-defined, and in these terms are applicable to students' descriptions of their normal work. Pask derives the operation/comprehension dichotomy from the earlier holist/serialist dichotomy;

"Holism and serialism appear to be extreme manifestations of more fundamental processes, which are induced by systematic enforcement of the requirement for understanding ... If the strict understanding condition is relaxed, as it is in class tuition or self-study, some students are disposed to act 'like holists' (comprehension learners) and others 'like serialists' (operation learners) with more or less success."

Pask uses these descriptions as the basis for a Test* designed to reveal students' tendencies to adopt one or other style. The aim of the present study was to compare students' performance on the Test with their performance in a selection of normal learning conditions. For most of the students, the 'normal work' conditions were slightly different from those previously reported here. In addition to describing their methods and the context within which they were using them, students began the session by being asked to 'teach back' the particular topic they were working on.

* The Spy Ring History Test, see Appendix 5.
The 'teachback' device was used as a way of externalising the student's thinking about the subject matter because I wanted to establish the content of the student's thinking on the task, as well as his account of his approach to it. The description of this technique in Section 3.5.1. shows that the student's account was not biased by the design of the task - the instruction given was neutral and allowed him to structure his account as he wished. It is possible, however, that the student's perception of my instruction could bias his account. If he shows no evidence of procedure-building, for example, that may be because he thinks I want descriptions. This point may be countered in three ways (a) there is no special reason for the student to assume I want one type of account rather than another; (b) the accounts were sufficiently lengthy and detailed to allow the opportunity for all types of account to occur, (c) the student's perception of what I wanted is likely to take second place to what he is able to offer. Insofar as these points meet the argument, it is then possible to view the teachback protocols as indicators of the student's style of thinking on a particular task, and the definitions of 'description-building' and 'procedure building' can be applied to his structuring of the subject matter. In addition, from the comparison of results on the Test, with those on the normal learning sessions, it can be established to what extent the Test reflects the student's normal learning style.

5.3.2. Results of the Spy Ring History Test

Pask's Spy Ring History Test, is designed to be an analogue of the kind of complex learning task that advanced students frequently encounter. Students are given factual information about a network of spies in three countries, together with rules about the transmission of messages, and the possible changes in the formation of the network. From this background information, and data on the actual sequences of transmitted messages over three years, it is possible to predict the formation of the spy ring network in the fourth year. In order to make a successful prediction, students have to be able to use both
Table 5.1 gives the scores achieved by 29 students on the test. Neutral scores (N) refer to the recall of factual information such as assigning spies to the correct country, and recalling facts about the spies and the countries. Operation learning scores (O) refer to the use and knowledge of rules and to the knowledge of sequences of transmitted messages. Comprehension learning scores (C) refer to the use of patterns and symmetries, to the knowledge of the structure of the network and the relations between spies, and to the use of non-essential factual information about the spies and the countries. Versatility scores (V) refer to the correct prediction of the formation of the network in the fourth year, i.e. the ability to combine facts, procedures and descriptions.

From the table it can be seen that most students (76%) have similar O and C scores*. This is to be expected in a group of students in higher education who should be among the more efficient learners. Pask emphasises that "both description building and procedure building operations are prerequisites for understanding any topic" (Pask 1976), and indeed it seems that, from the test scores, the majority of these students are capable of using both.

The interpretation of the versatility scores is problematic, however, as they do not reflect the equivalence of O and C scores. If versatility means the ability to combine both operation and comprehension learning without bias in either direction, then most of the students should have good versatility scores, and those who did exhibit bias should have low versatility scores. But this

* Similarity of scores, or a measure of bias, is given in Column 8 of the table, using Pask's formula \((0-C)/(0+C)\). If the absolute value of this figure is less than 0.4 then the students O and C scores are judged to be similar.
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Scores in %
is not the case. (See $V_{H/L}$ and $C^*$ columns in Table 5.1.) Only 3 of the 7 students who showed bias have very low versatility scores (i.e. in the lower quartile). Moreover, only 2 of the 5 students who scored very high (in the upper quartile) on both operation and comprehension learning, also scored high on versatility. Thus the versatility score does not reflect equal capability on both operation and comprehension learning, or "mastery of both the comprehension learning and operation learning components". (Pask 1977).

An alternative interpretation which may be derived from the scoring procedure of the test, is that the versatility score is, in fact, a measure of the extent to which the student is capable of going beyond the information he has from both operation and comprehension learning procedures. Operation learning gives the student information about rules and the details of sequences of messages. Comprehension learning gives the student information about the relations and structures involved. But in order to predict future sequences, which is what the versatility score is related to, the student has to use both types of information in a creative and productive way. Thus 'versatility' is perhaps something of a misnomer, and the score relates instead to 'independence' or 'productive thinking'.

The question now arises - to what extent can a student exhibit productive thinking if he has a poor memory? In order to make a successful prediction, the student must either be able to remember both operations and descriptions and then build on those, or he must be able to keep in mind the aim of the exercise and build his solution as he goes to avoid the load on memory. Very few students found themselves able to do the latter, as emerged in interviews*. In the former case, a student can only exhibit evidence of productive thinking if he has a good memory.

* These will be discussed more fully later.
The test can be re-scored to compare results on those questions that rely purely on memory, with those that require some form of 'going beyond the information given' or productive thinking. The expectation is that only those students who gain high scores on the memory questions will be able to obtain high scores on the productive questions. Students who score high on memory may or may not have high productive scores.

5.3.3. Re-scoring the Test

The re-scoring of the Test in this way alters some of the categories used in the original scoring procedure. (Details are in Appendix 5). For example, Question 5f:

"Which spies accumulate information?"

requires the student to use his knowledge of rules, and is thus productive, in contrast to 5a:

"A spy is always in a position to receive messages from one or more other spies, and to send messages to one or more other spies. True or False?"

which requires straightforward memory of the information given at the start of the Test. In the original scoring procedure, both these were classed as operation learning. In the second scoring procedure, 5f is classed as P (productive thinking), and 5a is classed as M (memory).

The results of this re-scoring are shown in Table 5.1 and plotted in Fig. 5.1. From the plot of the data it can be seen that, as expected, those students with low M scores also have low P scores, whereas those with high M scores have a range of P scores from low to high: in order to obtain over 24% on the P scores, the student must obtain more than 64% on the M scores. Any discrimination between students on the basis of their ability to use information should therefore take into account that this ability is dependent upon the ability to memorise.

* Gordon Pask has commented on my re-scoring, as a result of which two questions were reclassified. His letter is in Appendix 5. My report is in Appendix 5.
Fig. 5.1 Comparison of 'M' and 'P' scores on Spy Ring History Test. Heavy lines highlight the grouping of the scores, showing that a good M score is a necessary but not sufficient condition for a good P score. M scores relate to questions requiring recall of information. P scores relate to questions requiring production of new information.
The interpretation of the results of this Test has to be done with care, especially as the Test itself, and the scoring procedure, is still undergoing development. It would be unwise to conclude from the Test results alone that, for example, students who had low P and high M scores were, in fact, immature learners because they showed an inability to use the information they had. At this stage of its development, the Test should be supplemented by additional information on how the students perceived it. After the test session, each student was asked to write down his answer to the question:

The aim of the exercise was to use your knowledge of the rules of the networks, and the way they operated in 1985, 1986 and 1987, to predict how they would operate in 1988. Did you realise this was the aim? How did your attempts to learn the data relate to the aim? Please explain why you did what you did.

The written replies showed that all the students found aspects of the test difficult to understand, some questions ambiguous, and too little time to do what they felt was necessary to achieve the aim of prediction. This was true even of the high M, high P scorers:

"Personally I felt there was not enough information for me to be able to generate a network for 1988. I would have needed lots more information before I could have felt happy about my prediction."  Charlotte.

"In the last section ... a derivation from raw data could have produced more accurate results, but this was not attempted because of partially vague recall and time pressure."  Roy.

A particular problem that was mentioned by all the low P scorers was seeing how the prediction might be made at all. These students found it difficult to see any obvious relationship between the spy rings in the three years and could not find any basis on which to make a prediction. This explains how high M scorers could still be low P scorers:

"I did realise this was the aim, but my methods didn't relate to it. I couldn't see why you should be able to predict - I just waffled."  Jack.

"I did not grasp what kind of deductions or rules I was supposed to make from the previous years' data lists. Hence really all I could do was to learn the lists and graphs without any particular bias to one aspect or another."  Sheila.
It could be argued, perhaps, that differences in P scores reflect the students’ ability to cope with a highly demanding task and to work out what was being asked of them. However, even the high P scorers mentioned some uncertainty about those questions where they were asked to go beyond the information given:

"More time would be required to 'mull things over' before deductions could be made with any degree of certainty." Bill

"I found it quite hard to realise what was required of me after storing the information." Charlotte

"In the section where their roles were asked for, I did not fully analyse the data to get the roles as I had lost complete recall." Roy

Comments like this suggest that some good predictions were not fully thought-out deductions, as they may appear in the results.

5.3.4. Discussion of the Results

A full interpretation of these Test results is therefore difficult for the following reasons:

1. The versatility score neither reflects lack of bias towards operation or comprehension learning, nor coincides with exactly those questions that test the ability to 'go beyond the information given'.

2. A rescoring which compares memory with productive thinking ability shows that the latter is only possible when memory is good.

3. From questionnaire data it seems that the Test is so complex, and time pressure so great, that many students may not have the opportunity to exhibit their productive thinking ability.

For these reasons, it would be unwise to make any predictions about the students' normal learning capabilities on the basis of either V or P scores.

As I discussed earlier, most students had similar O and C scores. There is no theoretical reason why the two scores should be related, and Pask has shown, using Spearman's Rank Correlation Coefficient, that, for at least one study,
they are not (Pask 1977). The scores here, using the same test, produce an Rs of 0.57, which is significant at the 0.01 level. This unusually high correlation is perhaps not so surprising among university students who may be equally expected to develop both types of learning in accordance with their status as the most successful and efficient learners of their age-group.

To summarise: the Test is inconclusive on the 'versatility' results; and on the operation/comprehension learning results, shows that most students exhibit little bias towards either.

The Test itself, however, is an attempt to formalise a dichotomy whose roots lie in students' actual approaches to learning, and are defined, as at the beginning of this section, in terms of real subject matter. Using these definitions, it should be possible to examine students' normal approaches to work for evidence of one or the other style.

5.3.5. Application of the Dichotomy to Students' normal work

In order to examine the operation/comprehension characteristics of students' normal learning, it was necessary to find some way of gaining more direct access to the students' cognitive structure of a subject area than could be achieved via their own introspective accounts. Unlike the deep/surface processing dichotomy, the comprehension/operation learning dichotomy makes direct reference to the nature of the students' thought processes - whether, for example, he thinks in terms of descriptions or procedures. It is possible that information about this may emerge fortuitously from interviews with a student on his approach to a subject, but it cannot be elicited directly. The researcher cannot expect the student to make an accurate interpretative judgement of the way he thinks when this is defined in terms not normally used by students in talking about their work. The deep/surface dichotomy was generated partly from students'
accounts of their work, and can therefore be elicited in that way. But the comprehension/operation dichotomy was developed by exposing the students' learning strategies themselves, not their introspective accounts.

In order to gain access to the students' thought processes within their own subject areas, the 'teachback' method was borrowed from Pask and adapted to this purpose. 'Teachback' was originally used in the holist/serialist experiments to examine the changes that students made to the subject matter as taught. Students learned some (fictitious) information from a programmed text, and were then asked to teach it back. Some students preserved the order and detail of the information, others altered the order and changed or elaborated the detail. The direction of these changes indicated whether a student should be classified as holist or serialist.

In the present study, the 'teachback' idea was used as a way of eliciting students' thoughts about a particular subject area. They had all been taught in the same lectures, tutorials and laboratory classes, and they had all been told to work through the same assignment sheets. By asking each student to 'teach' the topic, protocols could be compared for similarities or differences on each of the two types of learning*.

The analysis of these protocols depends upon the careful definition of both operation and comprehension learning. These have been defined respectively in terms of procedure building and description building. With respect to the Spy Ring History test, they have also been defined in terms of rule-learning and structural-learning (i.e. of patterns, relations and changes in structure) according to the different types of information involved in the test. In order to use these definitions in the analysis of protocols of normal learning, it

* Further details of these sessions are given in Chapter 3, Section 3.5.1.1.
is useful to make the components of the two types of learning as explicit as possible. Additional components could probably be added to the following list, but it is sufficiently comprehensive to be useful in classifying these protocols, and the descriptions fit Pask's original definitions while also making them more explicit.

**Operation learning**

- $O_1$ Uses definitions.
- $O_2$ Uses procedural or relational rules.
- $O_3$ Makes logical derivations.

**Comprehension learning**

- $C_1$ Compares or distinguishes theory and practice.
- $C_2$ Interprets theory in terms of, or refers to, the real world.
- $C_3$ Introduces (strictly) redundant or irrelevant information.
- $C_4$ Compares two or more situations; (e.g. finds an analogy) or considers a simplified situation.

The original definitions are not explicit. The three categories of operation learning suggested above are derived from the following descriptions:

"Operation learners pick up rules, methods and details ... If an operation learner is provided with a specific description (by external means) he assimilates procedures and builds concepts for isolated topics." (Pask 1976)

Comprehension learning is defined using the descriptions:

"Comprehension learners readily pick up an overall picture of the subject matter, for example, redundancies in a taxonomic scheme or relations between distinguished classes ... [they] describe the relation between topics." (Pask 1976)

The above definitions are also aided by Daniel's account (in Entwistle and Hounsell, 1975). This is based on an element of a domain map of a subject area, which shows the link between relations $R_a$, $R_b$ and $R_c$.

![Fig. 5.2. Conjunctive element in a domain map.](image)
"Operation learning is shown by the student who, having understood relations R_b and R_c, moves up to R_a and understands it by extrapolating his concepts of R_b and R_c and by using similar computing methods."

"Comprehension learning corresponds to sideways movement across a domain. It occurs when a student who has reached R_a in the figure moves to another element (e.g. R_x, R_y and R_z) and interprets R_x in terms of R_a."

"The pure operation learner can only climb vertically on the domain map without being able to transfer his understanding to other areas, whereas the pure comprehension learner is a cursory globe-trotter who sees analogies everywhere, but is unable to employ any concept in a practical way." (Daniel 1975)

The definitions suggested above are therefore attempts to make these descriptions of operation and comprehension learning more explicit so that students' protocols can be analysed in terms of the various components of the two styles.

Using these definitions, three pairs of judges analysed nine students' protocols. Of the nine, seven achieved on average 82% agreement (with a range of 75 - 89%) between the two judges without discussion, and this could be increased to virtually unanimous agreement with discussion. The remaining two protocols proved difficult for one judge, who was familiar with the subject matter, because he felt he could not classify statements that were wrong or confused. The rest of the analysis by the other two judges and myself was done by considering the nature of the student's reasoning, rather than its accuracy, as this was the aim of the exercise. With this proviso, it was possible to obtain high agreement on the analyses. In spite of the difficulty with the two inaccurate protocols, therefore, this exercise provides some validation of my analysis of the remaining data.

Examples of all the above components will be given to illustrate the application of this dichotomy to normal learning situations.

It may be useful, before beginning a detailed analysis of protocols to illustrate the range of students' thinking even within one particular topic area. Two
extended quotes are given below, where both students are talking about the interpretation of equilibrium diagrams in metallography. (See Fig. 5.3.). In each case the quote is the first part of the student's reply to the question "Can you explain this to me starting right from scratch?" Each quote is annotated with references to the categories defined above.

\( O_2 \) "Well basically you find alloy 1, so you follow that line and you’ve got temperature up here, you’ve got element A on this side, element B on this side and there’s percentage weights of these along the x axis … What you have to do is, there’s a rule that says that when you go across a solid section of a phase diagram – which is this bottom half, the top half is liquid – you go from single phase to double phase to single phase to double phase, across the bottom of the diagram. The loops here between the solid phase and the liquid phase is compositions of liquid and solid. It takes some time to cool down, and solid’s formed through that cooling range because you have two different elements at different melting points. You’ve got element A has a melting point of 800, element B is 300°C, so as you have different melting points, then the mixture of them, the melting point is spread over a range. So, if we now come back to region \( \alpha \), as solid \( \alpha \), so we put, you always put, when you work from left to right, you get \( \alpha \), then \( \beta \), then so on. So you call this phase here \( \alpha \). Now to find the composition of you go down to the point where it starts solidifying which is this line here. Then you follow it across to the line between that liquid, liquid and solid phase, to the solid phase, so you follow this across, and it hits this first line here which is about 2% B so you say OK at that temperature \( \alpha \) has a composition of 2% B."

David.

"Well basically this is an equilibrium diagram taken of an alloy. At one end of the diagram we have pure metal A, where pure metal B is at the other end, so you’ve got mixtures i.e. alloys between that point in different proportions. These diagrams were made by people, who were very dedicated, sitting in little attics and things years ago, by doing cooling curves on certain metals, or alloys, in certain proportions, noting from the liquid phase what
Fig. 5.3 Equilibrium Diagram referred to by students.
happened as the metal cooled down. They would note the temperature at which the solid would start to appear, and then the solid would be with the liquid then for a certain temperature range, then at the end of that temperature range, there would be all solid, and that temperature too was noted, and it would cool right down to purely solid. Then a lot of these were plotted, all the way across, and this would give a graph from all the different points. Also this was done for solids, the difference between two solids ... there are some reactions that happen in the solid state rather than just in the liquid state and these were done by metallography, actually cutting things up, looking at them, noting what's actually there. Well basically, the diagram allows you in theory to predict which phases of an alloy will be present at any time, well, at any temperature and any composition.

That's it in theory; it doesn't actually happen in practice which we've been told so far. So by following any proportion of alloy down, from, which starts at the liquid state, at any temperature, we can say, well, what's actually there."  George.

The two explanations here serve as contrasting extremes of the possibilities available to a student. The second student never got around to explaining the actual procedure used on equilibrium diagrams, the first student explained nothing but procedure. These very obvious differences are reflected in the categories assigned to the two protocols: mainly operation learning for the first student, and mainly comprehension learning for the second. On the Spy Ring History Test, however, neither student showed a strong bias towards either type of learning.

The above quotes suggest that it is indeed possible to apply Pask-type definitions of the two types of learning to students' accounts of normal work. They are not usually so consistently one type throughout an entire passage, however, and the remaining illustrative quotes for the different sub-categories will be shorter extracts, designed to illustrate the classification used on the protocols. All extracts come from the nine students who talked about equilibrium diagrams in one of their sessions. Thus all of them refer to the same subject area as the two quoted above.
Although the subcategories of operation and comprehension learning have been designed to fit protocols of this type, there are still some occasional problems of interpretation, and possible overlap between the definitions. For this reason, each one will be discussed separately.

The sub-category $O_1$: 'uses definitions' is normally straightforward to identify, but can sometimes appear to overlap with $C_2$: 'interprets theory'. For example, the following extract has been classified as $O_1$ (uses definitions):

"... the loops here, between the solid phase and the liquid phase is compositions of liquid and solid." David

even though it appears to be interpreting the abstract diagram in terms of what it refers to in the real world. But it is a simple statement of definition, it is not an explanation because it does not go beyond the descriptors of the diagram. This can be compared with a similar extract that has been classified as $C_2$:

"... above this percentage, which varies with temperature, you can't dissolve any more of B in A in the solid state" Liz

This also relates a region of the diagram to the real world, but it is not a definition, it is an interpretation. Whereas the first extract simply states the referent of the diagram, the second states what it means for the real world referents. The latter is more than a simple naming of parts.

5.3.5.1. Examples of Operation learning

Further examples of 'using definitions' are as follows:

"That's the $\delta$ region with carbon soluble. This is eutectoid reaction here. This is your $\alpha$ phase. This is a two-phase region, which is a mixture of the $\alpha$ and the carbon compound ..." Arthur

"... this line ... is called the liquidus, and by liquidus it means that everything above it is liquid ..." Brian

"This is the peritectic. It's called the peritectic because of that pattern there. It's that pattern there that defines it as a peritectic. It's a characteristic pattern." Ronald
The second category, $O_2$, 'using procedural or relational rules', refers to those standard procedures employed as a technique of problem solving or as part of an explanation.

"... if we're at a certain point, say that point, we can find out the proportions of $\alpha$ and $\beta$ by taking the proportions of length of the line ..." George

"Then 12.5% A, working from this side of the graph, which is % A, 100% B, you work from this side of the graph, you get 12.5% A, as temperature is raised solubility is increased." Sean

"Now, bring in that rule, anything in between those two single phases, you've got a double phase, so that's a double phase ..." Thomas

The difference between a procedural rule and a relational rule is that the former amounts to a standard procedure, or is used as one, as in the last quote above, whereas the latter is closer to being a definition:

"Now then, we've got a straight line. Now then another rule is that if you've got a straight line ... that is a compound." Thomas

In the case of both procedural and relational rules, they differ from definitions in that they allow the student to progress from known information, to a further stage in the explanation or solution to the problem. Rules provide the standard links between the various concepts within the subject matter.

An alternative way for the student to progress through the subject matter is to make links by 'making logical derivations', as in $O_3$:

"... because (you have two different elements at two different melting points) ... then the mixture of them, the melting point is spread over a range ..." David

The reasoning involved may not always be strictly logical, it may sometimes appeal to common sense, or even to an understanding of some component part of the argument as in the quote below:

"...(if it has pure A, at 830 ... it would solidify and then it would form pure $\alpha$ below that. But you haven't got a mixture of the two,) so ... it's a lower temperature where it starts to solidify." Helen

The connection made here depends upon some knowledge or familiarity with the way metals cool, but the link is a derivation rather than a standard procedure.

The same is true of the following two quotes:
"(some of it comes out in the form of a $\beta$ solid solution which is richer in B), and so the composition of the $\alpha$ decreases in B, and the composition of $\beta$ increases in B. Reasonable?" Brian

"(You can't dissolve any more of B in A in the solid state), so you get the second phase coming out which is the phase which is mainly B." Liz

Both these are appealing to commonsense: if one understands the concepts 'richer' and 'can't dissolve any more', then one can follow the logic of the argument without recourse to special knowledge.

These operation learning characteristics of the students' learning have all been concerned with procedure building in some way. The arguments, statements, and reasoning involved are all focused on the details of the subject matter—the definitions, rules, and procedures that amount to 'doing a problem'.

5.3.5.2. Examples of Comprehension learning

By contrast, the comprehension learning characteristics relate to description building. Here the students show evidence of thinking about what the rules and definitions refer to, their interpretations and implications. Here they are thinking about what is going on behind the more formal aspects of the subject.

The first category, $C_1$: 'compares or distinguishes theory and practice', is relatively straightforward to classify. It refers to those occasions when the student considers the limitations of the theory, the approximations it contains, the assumptions that it makes, and compares these with the reality it attempts to describe.

"... under equilibrium conditions it quite often doesn't happen, because you've got to get the atoms rearranged, and so on." Liz

"... really this is an ideal equilibrium diagram, assuming that the peritectic temperature happens simultaneously, but when you think what it is, obviously that's impossible to go simultaneously through the liquid plus $\alpha$ to the $\beta$ plus $\alpha$, so really the peritectic temperature lasts for quite a while." Ronald
"Basically the peritectic, it doesn't actually happen very 
often in practice, and you can more or less forget it after 
you've done it in theory." George

In all these cases, the flow of the argument has been interrupted to stand 
back and consider for a moment, the reality it refers to. They vary in their 
sophistication and the amount of factual knowledge they make use of, but the 
overall characteristic of comparing theory with reality is the same.

A slightly different characteristic occurs as C2: 'interpreting theory in 
terms of, or referring to the real world'. This does not contrast theory with 
reality, but sees one in terms of the other - in this case the two are treated 
as congruent. There may only be short references to the interpretation 
embedded within a purely theoretical account, (as in the first quote below, 
where the interpretation is immediately followed by definitions of different 
parts of the diagram), or there may be a more extended account of what, in 
theory, is happening.

"If you've got pure iron and you elevate its temperature you 
get structural changes with increasing temperature, (at 910 
you start off with the first structure you call α ...)" Arthur

"(...) if we take any point, if we increase the temperature, you 
find that the graph will go this way) and you get more and more 
B dissolving in A, as we're going towards B, as we're raising 
the temperature ..." Sean

"You've got crystals of 2% B come down first of all ..." Brian

All these are interpretations of the equilibrium diagram, explaining how it 
relates to the reality, but all are fairly brief. A more extended interpretation 
is also possible:

"In some ... types of material, a lot of them when they freeze, 
metals that is, you get two distinct crystal patterns. In a 
particular metal, you could end up with one phase with dendrites 
in it ... each, well say in α that one, and in the β phase that 
one, they're two completely different phases and so, because a 
lot of metals aren't completely soluble when they start to freeze, 
you get these two phases out." Thomas

In this case the student describes what can happen in reality and then shows 
how the diagram, the theory, corresponds to this. Thus theory and reality are
not compared as they are in \( C_1 \); instead they are considered together, the one being interpreted in terms of the other, the two are compatible and well-behaved.

The third type of comprehension learning, \( C_3 \), *introducing strictly redundant or irrelevant information*, is not derived from any of Pask's definitions of comprehension learning, but from the scoring on the Spy Ring History Test. The concept is similar to one characteristic used to identify the holistic learner ("evidence suggests that the holist is assimilating information from many topics in order to learn the aim topic" Pask 1976). It is manifested in the Test in the form of questions that relate to the students' use of geographical or political information about the countries. This is not directly relevant to the main task set by the Test, but some students may make use of this type of information, for example, to aid memory. There are not many examples of this particular characteristic in the protocols under discussion here, and perhaps the best example has already been given in 5.3.5. The historical information on the origin of the diagram was not strictly relevant to the problems the students were asked to do using it, yet clearly, for this student, it had some value in making the diagram meaningful. Only one other student explained it in a similar way by describing how the diagram might be generated in the first place.

"... so you mix different alloys at different temperatures, like if you take 20% B and 80% A, you heat them up, the right percentage of the metals, melt them, and then you put something that measures temperature in, and you cool it, and every so often you take the time and the temperature and now here, they've found out what the structure was, you find out whether it's liquid at the different temperatures ... then as you cool down, you see what the structure is ..." Helen

The use of the words 'redundant' and 'irrelevant' should clearly not be seen in any pejorative sense; the word 'strictly' should take its full force. The use of such information may be compared with the use of concrete examples of a theoretical process to aid understanding, or the use of an amusing anecdote to
aid memory. The information invoked is pertinent and possibly helpful to understanding, but it does not in itself advance the solution of a problem or the execution of some theoretical procedure.

The final comprehension category, $C_4$: 'using analogies', involves interpreting one concept in terms of another. Consideration of a simplified situation is here assumed to be a special case of finding an analogy. Thus any occurrence of a comparison between two situations on the basis of some essential similarity or difference between them, may be classified as $C_4$.

"... if it has pure A at 800°C it would solidify, and then it would form pure $\alpha$, below that. But you haven't got pure A, you've got a mixture of the two, (so it's a lower temperature where it starts to solidify ...)" Helen

"Something like copper sulphate only combines one copper with one sulphate ... the copper doesn't take two, three or four sulphate, it only takes one. So the same applies with that. That [vertical line] could be MgPb or it could be MgPb$_2$, it could be a compound ..." Thomas

"(... you've got a saturated solution.) It's like cooling down salt in water. Some of it comes out in the form of a $\beta$ solid solution ..." Brian

The second two quotes are clearly analogies, where the student gives an example of a particular process by comparing it with a similar case - i.e. a sideways movement across the domain. In the first quote a contrast is drawn between two situations. This means they are comparable in some respects, but the comparison draws attention to an important difference and its consequences. Such a comparison may involve moving from one level of the domain to another since one case is simpler than the other; indeed the comparison may be made expressly to highlight the fact that the focus situation is on a different level of complexity. This does not correspond to the description of a 'sideways movement across a domain', but it seems reasonable at present to combine this special case of contrastive analogy with those analogies that are on the same level, at least until such time as there is a good reason for separating them.
These comprehension learning characteristics exhibited by the students correspond to different aspects of description building. Description building allows the student to stand back from the details of procedure building, and consider the overall picture: the application, the interpretation, the relations between different parts of the topic. The sub-categories of comprehension learning suggested are applicable to the students' protocols obtained, and remain, broadly speaking, faithful to the definitions that Pask has given.

As the quotes testify, all the students in this particular group use both operation and comprehension learning. The proportions may vary from student to student, but there are several cases where operation and comprehension characteristics are closely mingled in the students' accounts. A full account of the equilibrium diagram requires, for many of the students, a constant alternation of comprehension and operation styles, as the following extract exemplifies:

"... you get these different diagrams, there's the plain sort of one loop with one of these lines in it, which is just a liquid and a solid forming, then you get the solid. And then there's the eutectic which doesn't have this bit here, ... you get two lines coming to the centre there, and you've got just one line coming down here, then you haven't got all these bits going on here, so you've only got one two phase region, which is this where you've got the solids in it, you wouldn't have this extra liquid and solid, it comes straight out and you don't get this difference in the change of the solid and liquid which in the peritectic you do ..." Helen

This combination of the two styles is reflected in most of the students' accounts of this topic and can be found similarly in their accounts of other topics. The versatility is to be expected if the Spy Ring Test scores are valid, as most students there displayed the ability to use both styles without particular bias. The categories are difficult to quantify, however, when applied to the protocols. The occurrence of the two styles may be compared quantitatively in terms of, say, the number of lines in the protocols classified for each, although it is possible, e.g. that comprehension learning
takes longer to describe than operation learning*. The figures given in the

table are therefore only a rough indication, and must be very heavily biased
in one direction before a student may be said to exhibit bias towards one or
the other. The table summarises the occurrences of different types of operation
and comprehension learning for each student in the different subject areas.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>ROY</th>
<th>DAVID</th>
<th>ARTHUR</th>
<th>BRIAN</th>
<th>LIZ</th>
<th>GEORGE</th>
<th>RONALD</th>
<th>SEAN</th>
<th>THOMAS</th>
<th>HELEN</th>
<th>AVERAGE O:C</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUILIBR. DIAGRAMS</td>
<td>76</td>
<td>87</td>
<td>60</td>
<td>56</td>
<td>70</td>
<td>18</td>
<td>8.5</td>
<td>59</td>
<td>19</td>
<td>59:41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>13</td>
<td>40</td>
<td>44</td>
<td>30</td>
<td>82</td>
<td>15</td>
<td>41</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-C/V_2(O+C)</td>
<td>1.04</td>
<td>1.48</td>
<td>0.4</td>
<td>2.4</td>
<td>8</td>
<td>-1.28</td>
<td>1.4</td>
<td>0.36</td>
<td>-1.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REACTION KINETICS</td>
<td>36</td>
<td>38</td>
<td>60</td>
<td>40</td>
<td>76</td>
<td>84</td>
<td>75</td>
<td>72</td>
<td></td>
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<td></td>
<td>70</td>
<td>62</td>
<td>60</td>
<td>24</td>
<td>16</td>
<td>25</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-C/V_2(O+C)</td>
<td>-8 (c)</td>
<td>-48 (c)</td>
<td>0.4</td>
<td>1.04</td>
<td>1.36 (c)</td>
<td>1.0</td>
<td>0.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEREOGRAPHIC PROJECTION</td>
<td>99</td>
<td>90</td>
<td>70</td>
<td>82</td>
<td>75</td>
<td>90</td>
<td>97</td>
<td>92</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1</td>
<td>10</td>
<td>30</td>
<td>18</td>
<td>25</td>
<td>10</td>
<td>3</td>
<td>8</td>
<td>87:13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-C/V_2(O+C)</td>
<td>1.96</td>
<td>1.6</td>
<td>0.8 (c)</td>
<td>1.28</td>
<td>1.0 (c)</td>
<td>1.6</td>
<td>1.28 (c)</td>
<td>1.68</td>
<td>1.68</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2. Comparison of classified protocols. Scores are given as a
percentage of the statements classified.

* A rough check on this was done by counting the total number of classified
lines in the protocols for the students with the highest C and O scores for
each of the three subjects:

<table>
<thead>
<tr>
<th></th>
<th>HIGHEST COMPREHENSION</th>
<th>HIGHEST OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUILIBRIUM DIAGRAMS</td>
<td>60 (RONALD)</td>
<td>37 (ARTHUR)</td>
</tr>
<tr>
<td>REACTION KINETICS</td>
<td>102 (ROY)</td>
<td>125 (RONALD)</td>
</tr>
<tr>
<td>STEREOGRAPHIC PROJECTION</td>
<td>128 (GEORGE)</td>
<td>126 (ROY)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>290</td>
<td>288</td>
</tr>
</tbody>
</table>

The quantitative comparability of the two scores suggests that there is little
difference between the two styles in terms of the amount of time (or words)
needed to articulate them. It is therefore reasonable to use a quantitative
summary of the data to indicate similarities and dissimilarities between
students and subjects.
The same measure of bias towards O or C is used here, as for the Test. The range of bias is different for each subject, but within a subject, those students are indicated who score on the extremes of operation or comprehension learning, compared with other students. A within-subject comparison shows that only Liz is consistently average, and two students, (Roy and Ronald), change from comprehension to operation learning on different occasions. A within-subject comparison, in Fig. 5.4, shows that the pattern of scores in the three subject areas is very different.

![Fig. 5.4. Comparison of operation scores between subject areas.](image)

These scores compare the amount of time a student spends in describing operation or comprehension learning. Insofar as this rough count can provide a comparison between students, Table 5.2. shows that the same student may exhibit different bias on different occasions. Fig. 5.4. shows that different subjects either require or encourage different proportions of the two types.

5.3.6. Discussion of the extension of Pask's work

The implications of these scores will be discussed more fully in Chapter 6, section 6.6. The results themselves, together with the detailed analysis of the students' protocols, show that all students use both types of learning as a matter of course, within their normal academic work. Occasionally a significant bias is indicated, but this does not suggest an inherent bias as the same student may show an opposite bias on a different occasion. No student is consistently heavily biased in one direction.
As with the results of the Spy Ring History Test, these analyses of students' normal academic work suggest these students are reasonably versatile in their approach to learning. The range of bias is very different however: on the Test, the (0-C)/½(0+C) score ranged from -.51 to .90; the scores from the teachback sessions range from -1.28 to 1.96. One possible explanation for the difference is the difference in the way the two types of results are scored. On the Test, students are scored as 0 or C according to their correct answers to questions that require operation or comprehension learning. They are therefore invited to use either style and, moreover, may guess correctly. In the teachback session, the choice of style is entirely up to the student, and guessing is not applicable. The opportunity to exhibit bias is therefore greater on the teachback sessions than it is on the test.

The relatively high versatility scores on the Test, and the unusually high correlation between operation and comprehension learning scores, both suggest that the dichotomy does not describe a characteristic of the student. This is borne out by the investigation of the two styles in the students' normal work. The contradictory biases some students exhibit, and the fact that bias is influenced by the subject matter, suggest that the dichotomy is more likely to characterise the student within a particular learning context. The extension of Pask's dichotomy of operation and comprehension learning into the study of students' normal academic work has rested on a number of assumptions: that the components as redefined in Section 5.3.5. reflect Pask's descriptions of the dichotomy; that students' teachback accounts provide an indication of the styles of learning available to them, and that the judges' interpretations of these are correct. I have tried to ensure that, as far as possible, these conditions have been met. The main problem in the analysis has been that the derived definitions do not reflect all the characteristics of the students' protocols, and a further study would extend these definitions to allow a fuller analysis.
The existing evidence suggests that the operation/comprehension learning dichotomy is highly applicable to students' normal academic work. It seems not to indicate inherent differences, however, and the hypothesis remains that the differences exhibited should be investigated in terms of the contexts within which they occur. This is the subject of the next chapter.

5.4. **Intellectual Development**

5.4.1. **Perry's work on Intellectual Development**

In his study of the forms of intellectual and ethical development of college students, (Perry 1970) Perry identifies a number of stages through which a student is likely to progress in his college years. The various stages constitute a scheme which describes the process of intellectual and ethical development in terms of the students' personal theories of knowledge and the nature of their personal commitments.

The main elements in Perry's scheme describe the different perceptions a student may have at different stages of development:

- A dualistic perception of knowledge as right or wrong.
- Teachers are authorities on right and wrong.
- Knowledge can be collected by hard work and obedience.
- Diversity of opinion is acknowledged, but seen as temporary.
- Diversity of opinion is legitimate (relativistic perception).
- Teachers may differ in what they want ("the student discovers qualitative contextual relativistic reasoning").
- Student makes a personal commitment in order to deal with his relativistic perception of knowledge.

Thus, the scheme represents increasing maturity in attitude to knowledge, in
particular one's subject, and attitude to authority, in particular one's
teacher. Both aspects are components of each of the stages defined by Perry,
so that the scheme embraces the student's whole academic philosophy, and
assumes that development progresses similarly in these two aspects.

5.4.2. Application of Perry's Analysis

In the present study, this scheme provided one basis for the analysis of open-
ended interviews. If the students' intellectual development does occur in the
way that Perry suggests, then the changes will inevitably affect his response
to his course and his method of working. It was therefore important to examine
the extent to which these students exhibited the characteristics that Perry
describes.

All 30 students were interviewed for 30 - 40 minutes about their general response
to academic life, covering questions such as how they felt about the course,
how they felt things had gone so far etc., although the direction of the
interview was dictated more by the student than by the interviewer (see
Section 3.2.1.2.). It is these protocols that provide some evidence of the
student's personal intellectual development, and which were therefore amenable
to analysis along the lines suggested by Perry.

This analysis shows that most of the students expressed implicit theories of
knowledge which were relativistic, even though the students came from different
undergraduate years (1st to 4th). Many of them showed a mature attitude
towards their subject, particularly in being excited by uncertainty, or in
actively seeking out mistakes:

"I like things that are really factual, plus if they've got a
bit of "we're not really quite sure about this", that makes it
even more interesting because then I can go and see what other
people say about it" Charlotte, 2nd year.

"You start going through the journals ... it's a question of
reading each of them through, finding out what the chap's saying ...
trying to eliminate where you think he's wrong." Chris, 4th year.
"There is so much going on in this area at the moment, there's a lot of new things being done, quite a lot of openings that still haven't been looked into in enough detail. It makes it more interesting." Susan, 2nd year.

"I pick up the books referred to in lectures ... it might be possible that the book may not be true, or the lecture may not be true, one of them may be making mistakes, or different notations, sort of comparing them." * Joe, 2nd year.

Some of the students described their progress towards this awareness of relativism, but always associated the earlier convictions of dualistic certainty with adolescence, as in the following quote:

"Something about light used to amaze me ... I was all the time thinking what is colour really, why things are different colours really, at school, when I was very young. Now the situation has changed, we are faced with more problems ... we have got more stories now to think about. Now my problem is multiplied by hundreds because now when I saw colour, a lot more things come ... Of course, we don't really know why things happen, but still we have got a regular pattern and see the connections between them." Joe, 2nd year.

This kind of recognition of legitimate diversity seems to be typical of this group of students - none of them showed the kind of naive dualistic approach to knowledge of their subject that Perry describes as the early stage of the college student's development.

A different level of maturity may be found, however, in the students' attitudes to lecturers. There were several stories of problems with the teaching, poor lecturing, or tutoring, which the students found themselves unable to cope with. They recognised a problem, but had not found a way to solve it, which meant they dealt with it in a rather unsatisfactory way. The following three quotes are examples of failure to cope with a teaching problem.

"In tutorials we usually get given sheets of examples and work through them. About 40 people. I can't see the point of them quite honestly ... usually a couple of tutors. If you're stuck in the middle it's a bit pointless trying to get any help." Tim, 2nd year.

"We have one lecturer who talks for 45 minutes and asks if anyone has any questions, and no-one is sufficiently well up on the subject to be able to ask intelligent questions, let alone say I don't know." Bill, 4th year.

* The use of the word 'true' here may appear to imply a dualistic perception of knowledge, but I think this would be a misinterpretation (a) because the student is foreign and occasionally uses a slightly inappropriate word and (b) the next quote from him belies a dualistic perception.
"I tend to be independent in a way, when I'm doing my project. I thought I could work out all the problems for myself, so I kept my mouth shut and at the end started opening it ... I feel I can learn more by going down to the library and look up books. I have this problem of communication with my lecturer. You're working on something new, and he comes to you with all this jargon, I couldn't understand him that well. I think I get nowhere by listening to him, I get confused." Isaac, 1st year.

Problems of this type, and the failure to cope with them can occur at any stage of an undergraduate career, although they are less common towards the end. By the final year, some students can report progress towards coping with teaching problems, and being able to make demands of the lecturers, unlike the three quoted above.

"Thermodynamics was a standing joke. Nobody understood a word of it ... now we'd scream 'whoa' and 'how do you get that' and be generally embarrassing, but then we just wrote it all down." Ian, 4th year.

"I read through my notes and went to the relevant lecturer, so I made sure I understood it all before I tried to learn it ... I've got to the stage now where I don't mind asking a lecturer to slow down, but in the first year it did cause problems. In fact with the bad lecturer, I ended up not revising his work at all." Katy, 4th year.

Once this stage has been reached, students are able to demand help from the lecturers as they need it, rather than simply wait until it is offered. Some students are happy to do this early in their course, as two 2nd years testify:

"Maybe I go to the lecturer in question and see what he said about it, because I found that was quite useful in the past. They're quite good about that." Caroline, 2nd year.

"Tutorials are what you make them. If you haven't any questions, you sit there and stare at the wall for an hour, no one will ask you any questions. But if you ask for help, someone will try and help you." Robert, 2nd year.

Thus far, the correspondence with Perry's findings is closer for the students' ability to cope with academic problems, than for the development of their epistemology. A relativistic perception of knowledge is the norm for these students, and indeed may even be the mainspring of their interest in their subject. There is, however, a clear development in the responsibility they take on for coping with academic difficulties. This is analogous to Perry's
idea of 'personal commitment'. Perry defines personal commitment in particular as e.g. a choice of career, and in general as a choice of e.g. the system of values the student might adopt. The concept therefore taps a large part of the students' personal life. It is very wide-ranging, and covers far more than most of the interviews in the present study. Part of the concept of personal commitment, however, is applicable, as it concerns an awareness of personal responsibility for the way the student conducts his life. Thus in progressing towards an ability to make demands of the lecturer, the student is taking personal responsibility for his academic survival. The 'personal commitment' is to academic survival.

This 'active personal responsibility' manifests itself with respect to the students' discussion of 'understanding', which is seen to require some activity on the part of the student rather than simply a passive acquisition of knowledge.

"If a lecturer presents an equation to you ... you can either accept it immediately, or go through something from very first principles ... you assume certain relationships and from then on you are dealing with an idealised subject ... and you then analyse what will happen and you end up with one expression that will explain what happens ... So understanding means/appreciating where it came from, appreciating each of the individual components, why they link together and what the result means." James, 4th year.

"By understanding I don't mean reproducing it, but having it there in front of you and being able to explain it to someone else." Katy, 4th year.

"I enjoyed doing maths more than the other sciences ... I like getting involved in a problem rather than just writing lots of notes, and learning and having masses of facts in my head ... learning facts you just have to keep reading them to memorise them, but if you've no need to remember facts, you can develop a more active mind. You're not just relating tons of knowledge, you're learning to use it." Tim, 2nd year.

This kind of active involvement in understanding may also be developed over the period of a university course:

"For understanding in the first and second year I would have said being able to reproduce it off the top of your head. But this year, with the problems being set, it means being able to
play around with things. I suppose really it means being able to apply a lot of things you know from other fields ... this year it's a deeper level of engineering sense which should just be natural." Chris, 4th year.

Here the level of intellectual involvement in understanding progressed from rote recall to a more intuitive feel for the subject.

5.4.3. Discussion of the results

This analysis of the students' personal theories about their academic subject has shown that, unlike the group investigated by Perry, they do not in general exhibit a development towards a relativistic perception of knowledge because they have already acquired it. However, there is a form of intellectual development taking place that is analogous to some aspects of Perry's scheme. The level of responsibility taken by the students determines whether or not they can cope with teaching and learning difficulties, and the extent to which they are actively involved in their own learning. This is a form of personal commitment and is a development over the period of the university course.

In Perry's scheme the sophistication of the student's epistemology is seen as developing in parallel with his level of personal commitment. But this is not the case here. The components of Perry's scheme are applicable but not the stages, or 'Positions' as defined, as they conflate the two types of development.

Entwistle (1977) criticises Perry for concentrating on the student's perception of relativism in a personal sense, rather than considering how well they apply this to their academic work. The interviews used in the above analysis aimed at being specific about particular courses and lecturers, and this led to the emergence of the two possible types of development; of epistemology and of personal commitment. However, as in Perry's study, it is not possible to assess from interviews alone how successful a student is in applying a relativistic epistemology to his work, nor indeed whether, in a science subject, this would
in fact lead to academic success. In order to relate the students' level of epistemological and personal development to academic success, it is necessary to posit some model of the nature of this relationship, and is therefore beyond the scope of this study, as no model is yet available. It is the aim of the next chapter to develop such a model.

5.5. Conclusions

The three studies in this chapter have all considered different aspects of learning as defined by other research studies. In applying these to the students' normal work, it seems that

(a) the characteristic styles are applicable, and do describe how students work in practice, but

(b) the application to normal work reveals that the various styles are context-dependent.

The fact that in the extension of both Pask's and Marton's work into normal studies, individual students are seen to use different styles on different occasions, suggests that students are responsive to contextual conditions in determining how they work. This is less true of the extension of Perry's study, which because it was based on students' general perceptions about their work, was not capable of demonstrating contextual dependence. The present study has shown that aspects of Perry's work are applicable to these students, but it has not challenged the assumption of consistency of, e.g. level of personal commitment, for each student.

For the styles and strategies of learning investigated, however, the evidence suggests that these vary within students, according to the contextual conditions. This raises the question: how and why do these differences occur? What contextual conditions affect the various styles, and how do they operate?
6.1. **Introduction**

The aim of this chapter is to synthesise the results reported in the study so far. In Chapter 5 I presented evidence to demonstrate that deep and surface processing, and operation and comprehension learning, describe characteristics of student learning within their normal academic work, but do not discriminate between individual students consistently. Since it appears that students exhibit different characteristics on different occasions, it is important to discover how the circumstances of a particular learning situation can contribute to determining how the student learns on that occasion.

In attempting to explain this, my aim is to find a common pattern between the students' responses to the various learning situations i.e. to find a model of the teaching-learning process that describes and summarises the data presented.

The first part of this chapter argues the case for attempting to develop such a model, and then describes how this development took place. The next part analyses further data from the exploratory studies which can help in the synthesis of data from the extension studies described in Chapter 5.

The model as developed is interpreted through a series of case studies of different students in various learning situations. The aim is to show how the model can explain the occurrence of different learning styles and strategies adopted by a student according to the circumstances within which he is operating. Finally, I discuss the strengths and weaknesses of the model in terms of its purpose to synthesise and explain the data presented.
The ultimate aim of any educational research must be to improve the practice of education, probably through an increased understanding of 'the educational system'. This begs many questions about what is meant by 'improve', 'practice' and 'education', but the essential point is that education is an applied subject, and if educational research is not applied, it is nothing. Present disciplines such as psychology have the luxury of doing pure research that may turn out to have some practical value. But educational research must have a clear orientation towards its ultimate practical application. As I argued in Chapter 2, the mutually interactive nature of the components of any educational system means that it must be looked at holistically. We cannot break the system into arbitrary components for investigation without considering the interaction of each component with the others. If, for example, we investigate students' problem-solving strategies, this must be related to other components, such as teaching methods, before any results can be implemented. The applied nature of the subject requires a holistic treatment.

A fully holistic treatment is scarcely practicable, however, as the scope would be too great for any one research study to cover. It must be permissible for an individual study to focus on one section of the teaching-learning process, but such a study should only be designed with reference to the larger context, and certainly can only be implemented if these other factors are taken into account. For example, Pask has identified two different styles of learning, comprehension and operation, but in order to make use of this, it is important to establish the conditions under which they occur, and the major factors that affect them. It is not sufficient to know that they exist - we must also discover under what circumstances they exist.

In order to permit individual studies to be focussed, and to be able to make
use of them, it is important, therefore, to have a general description of the teaching-learning process under which they can be subsumed. We need a model of the teaching-learning process that delimits the main factors affecting student learning and postulates the relations between them. If a model is available, it will then be possible for the results of individual studies to be developed into practical guidelines for implementation.

A model of this kind would act as a modus operandi for a research programme. It would always be temporary, in expectation of being modified or further developed, and any practice developed from it would have to be experimental. But there must be some kind of systematised model if educational research is to be anything more than an aggregate of different kinds of research studies.

There has been a general cautiousness about developing a theory of education or, less ambitiously, a model of the teaching-learning process. This is justified by the complexity and difficulty of the task, and by the lack of substantial research on which to base a theory or model. But we cannot avoid the responsibility of developing something like a model because of the complexity of the process: as long as it is not inherently impossible to describe the educational process in simplified terms then the possibility of a model that can act as a modus operandi for research must exist, and must be realised.

The purpose of the model would, in part, be to provide a theoretical context for research, development and implementation. A further advantage of a model is that it makes assumptions and conclusions both explicit, and highly accessible to criticism. It is easier to see the gaps and the contradictions than when the model remains implicit, as it often does.

Insofar as the present research study can generate a model of the teaching-learning process, it should be seen not as a tried and tested theory, but as
(a) an explicit summary of the research findings, and (b) a basis for further development of a simplified description of the educational process. The acceptance of (b) depends upon the validity of (a).

6.3. Development of a model

The initial reason for my attempting to develop a model at all was that it helped to systematise the research. At the end of the pilot study the replications studies had largely failed, but the open-ended exploratory study had generated a number of factors as being of possible importance in a study of student learning. Not only did this part of the study expose some of the main factors affecting student learning, it also gave some evidence of the relationships between them. In order to study these further it was necessary to describe them in such a way that the description summarised the evidence at that time, thus making the gaps and inconsistencies obvious, and assisting the design of later research. This summary description was, in essence, a hypothetical model.

The first draft of the model distilled from the students' descriptions, four main factors that influenced their study methods. These were linked as factors in the model, where directional lines should be interpreted as 'influences'.

Fig. 6.1. First draft of a model of student learning.
Fig. 6.1. shows the first approximation to a summary of the data gained from the pilot study. The value of the model was that it generated further investigation into the relationships between the last three elements by suggesting a study of specific learning tasks. The remaining stages of the research utilised this idea by investigating students' perceptions of their work on selected topics within their courses. The model also postulated a particular type of relationship between the first three elements that was further investigated by the continuing use of open-ended interviews, and an additional interview about the students' academic history. The existence of the model as a coherent whole emphasised the fact that there was very little data on the relationship between 'overall motivation' and 'specific goals', and this also required further investigation.

After the data from Stage G of the study had been collected, it was analysed in terms of the model and contributed to its further development. One change that became immediately necessary as a result of the work on selected topics was the introduction of 'the nature of the subject matter' as an element in the model. A more complicated change occurred in the light of more information about the students' overall motivation. Firstly, it became clear that 'motivation' was an inappropriate concept. The data did not describe what impelled a student to use particular methods, nor did it describe some constant characteristic of the student. Instead it revealed the nature of the factors the student was taking into account in deciding on his study methods. It therefore seemed more appropriate to characterise this as 'orientation'. It also became clear that a student's overall orientation should have primacy of position in the sense that it appeared to influence his perception of the teaching and assessment, rather than vice versa. In a similar way, 'attitude to subject' was relegated to being one manifestation of a student's overall orientation.

With the accretion of new data, the first draft of the model became inadequate.
as a summary; it had to become more general, and more complicated to be capable of summarising the new information. It became clear that some parts of the students' descriptions of their working methods could find no place in this kind of model: descriptions of changes in working methods, for example, required a time component that could not be included without radically changing the nature of the study to a longitudinal study. By the end of Stage C, therefore, a model was emerging that was both more sophisticated, and more obviously limited in its scope. In the remainder of the study, the model continued to develop as before, generating further data on those aspects of student learning that the study could deal with. The scope of the resulting model and its limitations will be discussed later in this chapter. The form of it may be summarised briefly here, so that reference may be made to it during the subsequent discussion of its component parts.

The model may be summarised in the following statement: A student's overall orientation to his course influences the nature of his response to the requirements of the task which, together with his perception of what these are, determines his approach to the learning task. This in turn, together with the teaching and nature of the learning task, influences the student's learning style. This is expressed diagrammatically in Fig. 6.2.

![Fig. 6.2. Final draft of a model of student learning.](image)

The model, as a distillation of the research findings, is thus an attempt to synthesise both the contextual and the cognitive factors involved in learning.
It does not cover all possible contextual and cognitive factors, but it does present a workable way of combining the two, and, insofar as it is valid, shows that the two types of factors can be integrated into a coherent description of how students learn.

This is essentially a cause-effect model, and as such it can attempt to unravel the complexity of interactions between components of the learning process into a simple, almost linear description of how they interact. The linearity is made possible by the fact that the various components of the model refer to different levels of the students' perceptions of the learning process, and the model suggests that each level interacts with a different aspect of the context of learning. Thus the cognitive processes involved in learning are seen as a series of decisions made at different levels of generality: decisions about the student's orientation towards his university work, his response to the assessment, his approach to a learning task and the choice of learning style within that task. These cognitive factors are linked to the contextual factors at different levels of the decision-making process, as they become important for the decision.

The model is therefore an attempt to describe the relationship between the cognitive and contextual factors of learning by considering the way the student makes use of them in determining how he learns.

The model will now be discussed in more detail, in terms of its components, its constituent relationships, and the evidence that can be adduced in support of it.
6.4. **Types of Orientation to Work**

The purpose of the exploratory part of the study was to allow the opportunity for other parameters of learning to emerge than had been foreseen in the replication studies. Analysis of the open-ended interviews produced the Perry-type components discussed in Chapter 5. It also became apparent that the students' 'orientation to work' was an important factor, and three different types have emerged. These may be described as 'academic' (interested in the subject), 'vocational' (interested in career opportunity), and 'social' (interested in general self-education).* These different classifications come from interview data, either as spontaneous self-description, or as answers to the questions 'Why did you come to university?', 'Why did you choose your subject?' or 'Why do you work at all?'. The students seldom ascribed to themselves a single overall orientation, although usually one would appear to have greater priority than the others. The different types of orientation should not therefore be seen as dividing students into three groups. Each student seemed to be aware of having all three types, but to varying degrees. Examples of the three types are as follows:

**Academic Orientation**

"The main idea which attracted me from childhood was the strangeness of things which happen in nature ... I think about physical phenomena all the time and it's something that wherever I am I can think about it and enjoy knowing why it's so ... I am preparing myself to work later on, hopefully on things I am interested in." Joe

"I've always been interested in Biology ... the fact that Microbiology is a new, expanding science, is exciting; so much to find out, or to disprove or confirm." Charlotte

"I did maths because I enjoyed doing the subject more than the other sciences ... I just enjoy doing it more than the others. I like getting involved in a problem rather than just writing lots of notes ..." Tim

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* Downey (1960) describes four types of educational aims as 'intellectual', 'productive', 'personal' and 'social'. The students' aims appear to conflate 'social' and 'personal'.
"On the industrial year, I did things for interest sake, just to see what happened ... I was doing research in my industrial year. I got a taste for research then. I had a project and just got on with it ... I was really raring to go, the weekends were dragging by. I really liked it because you were achieving something." Ian

Vocational Orientation

"I am aiming to reach a level of education that would help me in achieving my career." Isaac

"I thought I might do Chemical Engineering because I liked Chemistry and Engineering and the more I went into it I decided it was quite a good type of thing to do ... it seemed to have a bit of potential, and it's paid off because the past few years, chemical engineers have been getting good jobs." Chris

"The reason I'm doing a degree is to get the kind of job I want ... Studying is still a means to an end even now, I'm not doing it for fun... The end is the job I eventually intend to have." Roy

"I'd always been interested in the biological field ... I went to all the pharmaceutical companies and hospitals, asking if it would be best to get a degree. They all said it would so it went on from that ... it was assumed that everyone would go to university, but I made a point of going round and making sure it was the best thing to do ..." Katy

Social Orientation

"I don't see this as some great thing I've got to do. It's just that I've got to get a degree and I'll enjoy myself at the same time ... If I don't go to university I can't do half the things I want to outside, after." Robert

"(What are you aiming to get out of the three years here?)" "An enormous amount of fun. Broadening of horizons and so on, much more than one could have done by three years equivalent work at the same place I was at before, infinitely more." James

"I don't think the sole purpose of being at university is to get a degree. I think you learn a lot of other things as well while you're here, apart from things to do with your course ... I'm not doing a degree to get a good job. I'm doing it to get a basic education. Furthering my education. I think I've learnt a lot about people. I've developed other interests while I've been here." Susan

All the students' descriptions of orientation, whether related to work, choice of subject, or choice of university, could be classified under one of the
three headings above. While they were able to single out a priority, however, the students were frequently aware of more than one source of motivation:

"I got interested in metallurgy when I left school ... I always wanted to further my education. I found I enjoyed studying ... I found I got satisfaction from learning things. Having worked for three years, I could see clearly that to get a decent job in metallurgy, you had to have a degree ... the reason I'm doing a degree is to get the kind of job I want, but I'm here for more than a degree - the sports, the social life, the chance to be independent."  Roy

Within the first ten minutes of the interview, this student had shown himself to be oriented academically, vocationally and socially. As many students show a similar tendency, it is important not to try to uniquely classify each student under one type of orientation, but rather to consider them as predominantly oriented in one direction, or as partially oriented in each direction, but to varying degrees.

The type of orientation students have becomes important when it is related to their study methods. Two basic kinds of motivation have been defined as 'extrinsic' and 'intrinsic' (Entwistle 1974), where extrinsic motivation is based upon external reasons for action, such as to pass an exam, and intrinsic motivation relates to internal reasons such as doing something 'for its own sake'. Applying this analysis to the three types of orientation described above, it is clear that 'academic' should be regarded as 'intrinsic' and 'vocational' should be regarded as 'extrinsic'. Insofar as students have a social orientation, i.e. they are at university for things other than the study of their subject, they do not spend their time on academic work. This type of orientation is therefore irrelevant to the study method adopted, but is relevant to the amount of work the student does, which tends to be less than for those students who are predominantly academically or vocationally oriented. When the predominantly socially oriented students do work, it is for either academic or vocational reasons. The argument so far may be summarised as:
In continuing the analysis of students' academic work, I shall be concentrating on the reasons for working, i.e. intrinsic academic or extrinsic vocational reasons, rather than the reasons for not working which spring from social orientation.

6.5. **Explanation of the Teaching-Learning Process in terms of the Model**

So far, I have identified a number of parameters of learning that are applicable to students' normal academic work. Some have emerged during the study, and some have already been identified by other researchers. Each parameter identified can take more than one value, depending on the situation being described. It is the purpose of the model to describe how the values of the parameters relate to each other, but because these values are situation-specific, the model must be applied to situations, rather than 'in general'. The claim is that the parameters and the relationships between them describe an underlying pattern that is applicable to any student in any learning situation. The purpose of this section is to show how the values of the parameters operate within particular learning situations, and thereby to explain the occurrence of different characteristics for the same student, as described in Chapter 5.

Since the model is essentially situation-specific, its application has to be described in terms of a series of case studies of students within particular learning situations. The case studies below have been selected to illustrate contrasting interpretations of the model, and thus to show how it can account for differences within and between students in different situations.
6.5.1.  Case Study I (Ronald)

One of the things the model has to explain is how one student can use different
strategies and styles on different occasions, so the first case studies concern
Ronald who was classified on the 'teachback' as above average on comprehension
learning for one topic, and above average on operation learning for another.

How does such a difference occur?

After the teachback session on 'equilibrium diagrams' the student was inter­
viewed about his approach to this task. His description of his orientation
towards the task suggested that he was doing it for intrinsic reasons, because
it was interesting and he wanted to understand it:

"Once you understand it, it's pretty straightforward. It's
interesting. It's the basis of most metallurgy really. It's
the kind of thing you do all through the course so it must be
pretty useful. I suppose more than anything it's interesting
because it's relevant."

In aiming to understand it, the student engages in a number of deep level
processing activities:

"I just followed it through and worked out what he wanted and
then I worked out the reaction and I understood it after that."

It is this deep level approach that led the student to supplement the teaching
where it failed to give him what he needed to do the task:

"I found it difficult. He said we shouldn't have to use a book,
but I did use a book because I couldn't work it out without. I
referred to a book because I didn't understand the peritectic
reaction, it wasn't clear from the notes. I used it to work out
what was happening at the peritectic reaction."

The student therefore had to do some productive thinking in order to do the
procedural part of the task which the teacher had not provided; i.e. he had to
generate his own operation learning. The comprehension learning he exhibited
in the teachback was contributed by the teaching:

"You can't take notes, it's the way he says it. If he's explaining
that, the equilibrium diagram , it's a whole kind of idea really.
You either sit back and try to follow what he's saying, or the
only way to get any reasonable notes is to write down absolutely
everything he says. It's very difficult to take notes on."

* See Appendix 7.
The way the subject is taught means that the student does most of his thinking in the lecture, in following the story told by the lecturer, neglecting to take notes which means he later has to supplement his understanding from books. The descriptive approach of the lecturer gives him the opportunity to use comprehension learning, to interpret the theory and see its relation to the real world:

"You can say at this point there it looks like so and so, and you can see a slide. You don't have to visualise it, you can actually see it. You can chop up a specimen and put it under a microscope and see what it is."

The student's use of comprehension learning therefore comes mainly from what he gets out of the teaching rather than from something he has to contribute for himself. To summarise this interpretation of the model, it can be expressed diagrammatically:

![Diagram](image)

Fig. 6.3. Interpretation of the model for Case Study I.

The student's academic orientation, aiming to understand the subject, means he is prepared to go beyond what the teacher asks of him, he wants to understand the procedures involved to do the task properly and therefore contributes himself the operation learning that is missing from the lectures. But it is the teaching that helps him to use comprehension learning in his teachback account.
Under what circumstances does the same student use predominantly operation learning? Considering his approach to a different topic, 'close-packed hexagonal structures' in crystallography, his orientation is different. His orientation here is towards what the teacher requires of him in this task rather than trying to obtain a fuller understanding:

"... all I know is it's a way of representing the atoms in a unit cell ... They just refer to the position of the atoms. That's all I know really, but that's all you need to know to do it. You don't need to know anything else ... I don't really understand the concept of unit cells and translating one unit cell to another."

The student's orientation in this case led to a surface level approach, showing the characteristics of concentrating on it as a memory task, and not trying to relate it to other parts of the course:

"It's just simple logical progression, I didn't need to refer to anything else ... The only thing I gained out of this was I showed myself I could work through it. The more times you write it out, the better you remember it."

In this case the requirements of the task matched what the lecturer had given him in terms of the procedures needed to do it:

"We did some of it in the introductory lectures last term ... this type of notation makes it easy to understand ... you're just given the vector and if you use that one, it's easy."

What the lecturer did not do, was to help the student relate the topic to the reality i.e. to use comprehension learning:

"visualising it is difficult in three dimensions. It's all three-dimensional ideas, but you can only be told them in words and pictures, so unless you can relate that pattern to a three-dimensional structure you're not going to understand it. You see a couple of models, but that doesn't really help ... Tutorials make it more complicated because he tries to explain it by using as many examples as he can. But if somebody has got the wrong idea, that doesn't help. You can't help somebody, it's up to him."

This shows the importance of considering the student's perception of the teaching, rather than some objective description of it. It is clear from the student's account that the lecturer is trying to help the students relate the

*See Appendix 6.*
theory to the reality it describes, but this student's perception is that this is unhelpful. The teaching does not provide him with the ability to do comprehension learning. The task itself matches those aspects of the teaching that he does understand, so his surface level approach allows him to be content with that, and his resultant learning style is to reproduce operation learning:

![Diagram](https://via.placeholder.com/150)

**Fig. 6.4. Interpretation of the model for Case Study II**

The difference in the student's learning style between case study I and case study II derives from the different orientation and approach, and the way these interact with his perception of the contextual factors.

6.5.3. **Cast Study III (George)**

This student provides a contrasting interpretation of the model in comparison with Ronald, as he is classified as using above average operation learning on 'equilibrium diagrams'. Looking at the orientation of this student, and his approach to the learning task, the former is more extrinsically oriented, so the latter tends towards a surface level approach:

"I was trying to understand it so that when I come back to it again I should be able to use it in the exams. I must admit that some of it was guesswork."

He was oriented more towards the requirements of the task for the purpose of doing it, being able to use it, rather than towards understanding the subject as
a whole. However, the task required the production of operation learning, which could not be reproduced from the teaching.

"We don't seem to have been explained how to use it as a diagram. It's been explained to us as far as going from the diagram, between that and what's happening on the atomic scale, rather than using it and learning how to use it as an actual diagram and going into practical considerations."

Thus the student sees the teacher as offering the opportunity to do comprehension learning, to build descriptions, to relate the theory to reality, but the task requires procedures, which have not been given to him. His surface level approach means that he wants to reproduce what the task requires, rather than aim for understanding the whole topic. The discrepancy between what the teaching offers and the task requires means that there is little that he can simply reproduce. His teachback account concentrates mostly on the operational procedures involved because that is what the task is about, and here he is trying to reproduce what he can from the teaching. It is possibly his surface approach that means that, unlike Ronald, he cannot supplement the teaching by using books:

"The books are very general, they don't give you any help in using the diagram. They don't go into using the diagram in practice."

Summarising this diagrammatically:

![Diagram](image)

Fig. 6.5. Interpretation of the model for case study III.

The student's problem here derives in part from the fact that he sees the task as requiring simply reproduction, he is not doing the productive thinking.
necessary to supplement the teaching, he wants it provided for him:

"If the questions were set on things we had done in the lectures, that might be a better way round of doing it."

6.5.4. **Case Study IV (Sean)**

On the same topic (equilibrium diagrams), Sean is intrinsically oriented, like Ronald, and as a result, takes a deep level approach to the learning task: in trying to understand the topic he takes an active rather than passive approach:

"I try and imagine how the graph would go ... I try to look for awkward things" .... "I try to look for other things to back up the way I've imagined it" .... "I did try books, I went to the library" ...

It is clear that Sean is sufficiently motivated to work hard at trying to understand it, and he spent a lot of time on this, but in fact he felt he failed and only became more confused. The source of the confusion seems to have been the style of the lectures. They were too fast, did not allow him to get full notes, and did not clarify the various relationships between the theory and the reality as he felt he needed:

"I think the lectures are quite good ... but the lectures start with the easy bits, starting off very slowly and you can follow it quite nicely. Once it starts getting harder, they seem to go faster ... It's still difficult to relate these diagrams to those equilibrium diagrams. It would help if you could link the two bits of work up. I went to Jerry and he went through slowly explaining it so I could follow it ... I have some confusion in that it was a lot to think about at one time. It wasn't till I went to Jerry and he pointed out the oil and water analogy that I started to realise what it was."

Although from the evidence of the previous two case studies it seems that objectively, the lecturer was spending quite a lot of time on general description relating the theory to the reality, it was not done in a way that this student could follow - it was too fast, it was confusing, there was too much to think about all at once, and the books didn't help. When it came to the teachback session, therefore, all the student could do, in explaining the topic, was to stick to the format of the questions and reproduce the definitions and
procedures, without explaining them in relation to what the diagram referred to, i.e. almost pure operation learning.

It is for this reason that the model is described in terms of the student's perception of the context. The teaching and assessment could be described objectively, but what is important for the explanation of student study behaviour is the student's subjective perception of teaching and assessment. For Sean, therefore, comprehension learning is inhibited by the confusing style of the lecturer, and operation learning is encouraged by the nature of the coursework task. It is an example of an attempt at deep level processing that failed.

![Diagram](image)

**Fig. 6.6. Interpretation of the model for case study IV.**

6.5.5. **Case Study V (Liz)**

The final two case studies compare two further students talking about their work on the topic of the 'close-packed hexagonal structure' in crystallography. Whereas Ronald found it difficult to relate the theory to the real world, Liz immediately saw the connection, and it was precisely this that generated her interest in the subject:
"It's a very interesting subject ... being able to explain and calculate things that it's almost impossible to see even with a microscope."

This intrinsic motivation level led to deep level processing activities:

"You need to sort of work out the different types of structures yourself"... "I was aiming to visualise the structures."

Perhaps most important was that both the teaching and the books she looked at helped this student to put this subject in its proper context, to see its relation to other subjects and to the reality the theory was describing, i.e. the presentation, via lectures and books fostered the comprehension learning manifested in her teachback account:

"The general book on crystallography had quite a lot of pictures in it, packing of spheres, to help one visualise these different structures ... It relates to what we're doing in the materials course. The way he lectures certainly holds my attention so I tend to take more in."

Being able to relate the theory to the reality meant that Liz was more inclined to refer to what was happening at the atomic level, than were other students. In her teachback account there are continual references to the atomic structure that is being described by the theoretical constructs the students are asked to deal with in the learning task. Her greater use of comprehension learning may therefore be accounted for by her perception of the teaching as showing the relationship between this theory and the other parts of the course.

![Diagram](attachment:image.png)

Fig. 6.7. Interpretation of the model for case study V.
The final case study also concerns the 'close-packed hexagonal structure'.

Like Liz, Helen was intrinsically motivated by the subject, but by a different aspect of it.

"I enjoy it. I like it because it's sort of mathematical but it's also got atoms and nice regular shapes which I like. You can actually do problems, concrete problems about it. You can do some mathematics and work it out. You can usually check what you're doing and go backwards from your answer."

The nature of the deep processing activities generated by the student's intrinsic orientation were all related to the characteristics of operation learning and, as a result, her teachback account contained a lot of description of the mathematical aspects of the theory. She focused on those aspects of the teaching that gave her mathematical techniques for dealing with the structures:

"The worst thing is trying to visualise the shapes ... You've got to be able to visualise it this way and draw it this way. This is what Jerry's trying to teach us, that this is the way we ought to be able to do it. These are simple, but they're going to get more complicated."

Thus, for Helen, it was the mathematical aspects of the subject that were more important, and her perception of the teaching fostered this inclination towards operation learning.

For both Liz and Helen, their bias towards one style of learning was not extreme. Both exhibited aspects of the alternative style. But as with the previous case studies, the predominant style could be seen to relate to the student's perceptions of either the teaching or the learning task.

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![Diagram](image_url)  
**Fig. 6.8.** Interpretation of the model for Case Study VI.
In this respect, the form of the model describes the characteristics of students' academic work demonstrated by these case studies.

6.6. Discussion of the Model

At this stage, the model can now be described more fully, and perhaps more clearly. In the diagram below, the directional lines should be interpreted as 'influences'.

![Diagram of the model]

**Fig. 6.9.** Detailed model of the process of student learning.

Interpreting each stage of the model, in line with the various case studies described gives us a hypothetical description of the mechanism of student learning:
Intrinsically oriented students tend to see the topic being studied as a whole. They aim to understand it, irrespective of what the task itself requires.

Extrinsically oriented students tend to see the topic in terms of what the particular task requires them to do.

If the task requires productive thinking, i.e. there is a mismatch between what the teaching provides, and what the task requires, the students will attempt to achieve this using a deep level approach.

If the task is seen to require reproductive thinking or memorising, then the extrinsically oriented students tend to concentrate on this, taking a surface level approach to the task.

Intrinsically oriented students tend to take a deep level approach irrespective of the task requirements.

If a student takes a deep level approach, then his learning style will tend to reproduce whatever the teaching encourages, and will also produce whatever it does not encourage, thus achieving a balanced understanding that includes both operation and comprehension learning.

If a student takes a surface level approach, then his learning style will tend to reproduce that part of the teaching that is required by the learning task.

The model is thus an attempt to show how the various parameters of learning operate in different situations to produce characteristic styles and strategies of learning.
One parameter the model does not account for is the success or failure in the student's performance of a task. This becomes important particularly when there is a mismatch between the teaching and the task. We have seen one example (Sean) where, using a deep level approach, the student attempted to produce the procedures, or operational learning he needed. But in fact the attempt had been unsuccessful i.e. that his teachback exhibited incorrect operation learning. In another example, the student (George) used a surface level approach, attempting to reproduce operation learning from the teaching, but because the teaching was inadequate for him in this respect, he also felt his account was incorrect. It is therefore clear that this format of the model can suggest how differences in performance can occur, and a future study could elaborate this point by studying the students' perceptions of their performances as well as some objective measure of them.

One important feature of the model is that different aspects of the learning task appear at different levels of the student's decision-making process. At one level, the relationship between the task requirements and the teaching is important in determining the approach the student takes. To put it another way, the assessment may require either a reasonably full understanding on the part of the student, or it may require only superficial attention to parts of the topic. It is at this stage that the student may be seen as making a strategic decision about his approach to the subject: whether he takes an active role in his learning, attempting to integrate the various parts of the topic, or whether he takes a more passive role, concentrating on reproducing only what is necessary.

Operation and comprehension learning become important at the executive level of the process where the student is thinking in terms of the subject matter itself. It is here that the content of the task becomes important: whether it requires the use of procedures or descriptions. Both can be reproduced from the teaching,
but if the teaching does not encourage or provide the means for either type of learning style, then the student has to produce it for himself. But this is only possible if he is taking a deep level approach to the task.

It is possible, therefore, to integrate Marton's descriptions of strategies of learning, with Pask's descriptions of styles, by considering them as describing different levels of the process of learning. Pask stipulates that both operation and comprehension learning are necessary for understanding, and certainly both tend to be exhibited by students who appear to adopt a deep level approach. But it is also possible for a student taking a surface level approach to reproduce both these if the teaching provides this opportunity. In analysing the Spy Ring History Test, I suggested that much of the scoring of operation and comprehension learning related to items that were simply reproduced from the background material and relied on memory alone. The re-scoring showed that several students, who remembered the material well, could score high on operation and comprehension learning, but low on the questions that required productive thinking, 'going beyond the information given'. A simple measure of the amount of operation and comprehension learning a student uses is therefore not a measure of his level of understanding. The two together are a necessary but not sufficient condition for understanding. Thus deep level processing is characterised by some form of productive thinking and probably relates to what Pask defines as 'versatility'.

At the end of Chapter 5, I discussed characteristics of students' approaches to learning in terms of Perry's 'levels of development'. The analysis related to the students' general descriptions of their academic life given during the open-ended interviews. They are therefore not related to particular learning situations and for this reason it is difficult to integrate them into the existing model. It is possible, however, to use the model to suggest how Perry's descriptions might be investigated in relation to the effect they have on students' performance.
In Chapter 5, I suggested that Perry's developmental scheme included two aspects of personal development, only one of which was applicable to these students. Their epistemological development was generally similar and quite sophisticated in the sense that the students showed capability of relativistic approaches to knowledge. Their level of personal responsibility for their work showed some differences, however. This was characterised in the interviews by a preparedness to seek out the kind of information the students felt they needed, to ask questions in the lecture, to go to the lecturer for help, to select particular topics for concentrated work - characteristics similar to those of 'cue-seekers' (Miller & Parlett 1974). In the context of the model, these characteristics will play an important part at the strategic level, where the student decides on his approach to a topic: instead of falling into the trap of using a surface level approach to reproduce aspects of the teaching that are inadequate for the task, a student who takes responsibility for his learning will seek out what the teaching does not provide. The precise relationship between level of personal responsibility and level of processing is difficult to speculate on. It may be possible, for example for a student with a well-developed sense of responsibility towards his learning to take a surface level approach, as long as this is not associated with immaturity, but expediency, as I have suggested (5.2.2.). Thus level of personal responsibility may relate to the student's ability to match his learning methods to his aims, which certainly has implications for his performance, and could, in a future study, be investigated on this basis.

6.7. Summary

The point of the model is to summarise and explain the data presented in this study. It is incomplete as a description of the teaching learning process because it describes only specific learning situations, it is not time-based, etc.
and it is not a dynamic model e.g. taking into account the effect of performance. It does, nonetheless, provide a useful starting point for the development of further research, by making explicit the nature of the relationships between a number of important parameters of learning.

The model suggests that it is possible to relate students' perceptions of the context of learning, to some of the cognitive factors involved in the process of learning. This process can be seen as a series of levels of decision making about what the task involves, and different aspects of the context become important at the different levels. Thus it is possible, according to the student's orientation, and his perceptions of the context, for the student to operate differently on different occasions. The most important implications of this are that it is not appropriate to study learning in general, nor to separate out different parts of the learning process, nor to make the assumption that students possess individual characteristics in their approach to learning.

It may indeed be possible to show that students do possess such characteristics, but the present study suggests that these are more likely to occur, for example, in the way they perceive the relevant contextual factors, or the way they determine their orientation to their work. The particular cognitive characteristics identified so far do not seem to discriminate between individuals - the differences, if they exist, are more subtle.

To summarise the implications of this chapter: the study of learning should be done holistically, taking into account, and integrating, both the cognitive and contextual aspects of learning.
7.1. The Argument of the thesis

To summarise the thesis, it is perhaps best to begin by summarising the argument which underlies it.

At the core of education, in all its various ramifications of teaching, administration, research and development, is the student alone with his subject. That is what we are all here for, that is what the whole enterprise is about: the education of the student in his subject. It is therefore the business of educational research to elucidate what is going on at the core in order to assist the rest of the system in performing its ultimate task.

What has educational research been able to tell us about this? Two major points have emerged from the literature as being particularly relevant to 'the student learning'. One is the approach which aims to describe the cognitive aspects of student learning; the other is the approach that investigates the contextual aspects, the effect of teaching methods, assessment, organisation etc. The former has a long history in research at most levels of education, and some recent studies have looked at learning in higher education in more detail. Studies of the context of learning do not have such a long history. Several investigations, usually of the case study type, have shown that contextual factors can have an important influence on students, e.g. on their perceptions of the assessment system, and on their attitudes to the teaching. Both types of description are useful for an understanding of the process of student learning, but they describe different aspects of it and have not been integrated. The focus of the thesis has therefore been to answer the two questions (a) How far do these descriptions apply to students' normal working situations? (b) Insofar as they do, how do they relate to each other?
If the context does influence the student, what kind of effect does it have on his work and how do the causal links operate?

The first task was to generate suitable data for analysis along these lines. Early in the study it became clear that it was necessary to study individual, well-defined learning situations focused on a student working on a particular learning task. Many of the existing descriptions of aspects of learning have been developed in isolation from real learning situations. It was therefore important that the students should be talking about their actual experience as this provided a test of the applicability of the existing descriptions of learning. The contextual aspects could be described by the student in terms of his perception of the task, of the teaching appropriate to it and of its place in the rest of his academic work. In order to gain access to the cognitive activities involved in the task, students were asked to give a spontaneous account of the particular topic concerned. Both types of data were analysed with the help of the appropriate descriptors already identified in the research literature.

As a result of the analysis, it was possible to show that certain types of cognitive descriptors, namely forms of individual differences in learning style, were indeed applicable to the data collected, but not in the expected way. It was not possible to demonstrate that students exhibited consistent differences in their approach to a task, but it was possible to show that the differences were applicable to a student in a particular learning context. Thus the same student could exhibit different characteristics on different occasions. These results could then be synthesised into a theoretical description of just how the different types of learning situation (where 'learning situation' includes the task itself together with those aspects of the teaching and assessment that impinged on it) could lead to different types of learning activity.
7.2. Conclusions

The final outcome of the study is an account of how the process of student learning operates. The status of this explanation is hypothetical. The study has been exploratory and hypothesis-generating in character, rather than hypothesis-testing. At the beginning of the study it was difficult to frame a testable hypothesis because the parameters were not defined and the plausible relationships to choose from were too many and too complex. The study has developed a number of reasonably well-defined parameters of learning, and some plausible relations connecting them have emerged. The conclusions are therefore not operational specifications for the practising educator as they are only postulates, but as such they can provide a basis for a future research study. This point will be discussed in the next section.

Bearing in mind their hypothetical status, the conclusions of the study can now be summarised.

At the basis of the explanatory account is an analysis of the student's orientation associated with a particular learning task. This is inescapable because it naturally forms an important part of the students' descriptions of their work. Again this is not a simple discrimination between students on the basis of different types of orientation. It is not appropriate for a study of this type to try to categorise students; the point is to reflect their complexity as far as possible rather than suppress it. It is possible, however, to categorise the descriptions offered by the students. Three types of orientation can be clearly defined, but they can seldom be uniquely applied to individual students. A student may be conscious of an overall tendency towards one type of orientation, but for most students the tension between the three types allows the other two to emerge as well occasionally. Thus for any one learning situation, a student may be oriented either towards intrinsic, academic
considerations, or towards extrinsic considerations such as course requirements.

Social orientation describes those aspects of the students' accounts that refer to their orientation towards developing the personality, broadening the mind, learning about people. These are quite separate from academic considerations, as they are particularly concerned with a broadening of the student's education rather than a furthering of it. This type of orientation does not relate directly to the way students work except in the sense that it often provides a reason for not working. Insofar as a student does work, he is motivated either by intrinsic academic considerations, or by extrinsic, vocational ones.

When a student is intrinsically oriented, he is working because of his interest in the subject, because he wants to know more about it, because he wants to be able to use it, because he wants to explain things, because he enjoys doing it. It is in this situation that the student is most likely to be aiming for a deep intuitive understanding of his subject and is therefore relatively unaffected by the nature of any extrinsic requirements of him. The opposite is true of the extrinsically oriented student who is working because he wants a good degree, because he wants a good career. Here the nature of the assessment is crucial to the aims he defines for himself in his work. These may be directed towards intuitive understanding, or they may be towards e.g. mechanical problem-solving skills; the approach depends on what the assessment requires.

Thus intrinsic and extrinsic orientation are needed to account for the different types of responses to the assessment system.

As with orientation to work, it is possible to categorise the students' descriptions of types of assessment they are aware of, and the important distinction which emerges here is between types of assessment that require productive and reproductive thinking. On some occasions, students recognise
that the examination or coursework marker is looking for something more than the regurgitation of lecture notes. The student feels he is expected to criticise what he reads, to be able to solve different types of problem from those already met, and even to contribute some ideas of his own. This means that work for assessment of this type requires an active involvement in the subject, which has been previously defined as 'deep level processing'. In some cases, on the other hand, students recognise that the marker is looking for more superficial characteristics, such as the number of pages he writes, the number of diagrams he has, the right formulae or the standard method. In this case the student's approach is more passive, attempting to assimilate as much as possible at the expense of a deeper understanding, an activity previously described as 'surface-level' processing.

We can now say that the student's cognitive activity that takes place as a part of the learning process, occurs in three stages: orientation, strategy and execution. Each stage interacts with the relevant contextual factors in different ways. The type of orientation determines the nature of the student's response to the assessment, whether he works independently of it or with reference to it, the requirements of the assessment determine his strategic approach, whether deep or surface level processing, whether he is aiming for productive or reproductive thinking. So far, he is simply making decisions, but at the executive level, his cognitive activity interacts with other contextual factors, namely the style of the teaching and the nature of the learning task. These two together determine the type of interaction the student is likely to have with the subject matter. Both can require or encourage styles of thinking previously defined as 'operation and 'comprehension'. These apply to the treatment of the subject matter, whether it is considered in terms of its logical operations, definitions, derivations and procedural rules, or in terms of the interpretation of its theoretical components, its relation to the real world, its relation to other theoretical concepts. The teaching offers,
and the learning task requires a particular type of interaction. For any one learning situation, the two may or may not be the same.

It is characteristic of the reproductive or 'surface' strategy that it is a passive approach that can only make use of what the teaching gives, and does not contribute anything more. If, therefore, the teaching tends towards the comprehension style of description of the subject, but the learning task requires the operation style, e.g. the use of rules and derivations, then the student is liable to find great difficulty with it. Students who adopt this strategy are therefore vulnerable to discrepancies of style between the teaching and the learning task. On the other hand, if a student adopts the productive strategy, where he actively questions and elaborates the descriptions offered by the teaching, he will be better equipped to contribute whatever is necessary to cope with a discrepant learning task.

Throughout these various stages of the learning process, therefore, the cognitive and contextual factors interact. The methodological conclusion is that research on student learning should not divorce the two, but should be capable of taking both into account. The theoretical conclusion is that existing descriptions of differences in learning style or strategy have not penetrated the essential core of the differences that exist between students.

That there are individual differences between students, with reference to their academic work, is undeniable. From this study, the nature of those differences remains an open question. The only personal characteristic involved in this account of the process of learning is the nature of the student's orientation, but even this remains as a personal characteristic simply because the scope of the study has not been able to account for its derivation, it can only state its existence. An investigation of its derivation would require a longitudinal study capable of producing a dynamic model of learning, i.e. one that could
explain e.g. Entwistle's question about the effect of the outcome of learning on motivation to learn.

As far as the present study is concerned, the type of data presented does not support the existence of personal characteristic differences. They are not ruled out by the study, but they are not required to explain the data. Characteristics of learning strategy and style, such as those discussed here, are not subtle enough to differentiate between individual students.

Wherein might the essential individual differences lie? In terms of the existing model, they could occur at any of the three stages of orientation, strategy and style. These have been only broadly defined, and it is possible that more detailed descriptions of what is involved in each could reveal the nature of the characteristic differences between students. A future research study might therefore be able to build on these conclusions.

The ideological commitment underlying this research study, as mentioned in Chapter 0, had been to provide research results that would be of direct practical help to teachers and students. At the end of it I have to concede that I have only gone some way towards achieving this aim and that there is still much to do. However, the following results should at least make it possible for teachers and students to analyse more consciously and deliberately the processes in which they are engaged: and these should help further to reduce the gap between theory and practice.

7.3. Implications for a future study

Three main issues remain to be investigated immediately.
(a) The provision of a dynamic model. It is important to be able to give some account of the dynamic aspects of the learning process, in particular the relation between the two ends of the existing static model, namely the effect on orientation of the outcomes of learning. Students' experiences of and attitudes towards learning change over time, and no account of the learning process is satisfactory unless it can describe how some of these changes occur.

(b) More detailed descriptions of orientation, strategy and executive style. The existing descriptions of these are not sufficiently detailed to encapsulate the fundamental differences between individual students. If there are such differences, and this is a plausible assumption, the present model suggests that they may occur at any of the three levels where students' own characteristics interact with the contextual factors. The hypothesis would be that there are more fundamental components within each of these stages that have not yet been discovered. An attempt at a more detailed description of what happens at these points might reveal the nature of these components.

(c) A comparison of independent analyses of learning task and teaching style with the students' perceptions of these. The present study has provided only superficial independent analyses of the teaching styles and learning tasks involved. A more detailed analysis is necessary to provide a comparison with the students' perceptions of these. It has been found that students' perceptions of the same contextual factors differ, and a fuller investigation of this may well throw some light on the nature of the fundamental differences between students.

Investigating these issues requires a series of intensive, long term case studies. Such an investigation differs in style from much educational research, but the three defining characteristics are essential, for the following reasons.
(a) **Long-term:** A longitudinal study is necessary because a dynamic model of learning is only possible if learning can be observed over a long enough period for changes to occur and be studied. The day-to-day changes produced, for example, by the effects of a particular teaching method, need to be studied at more frequent intervals, and over the duration of, perhaps, one term. Somewhat larger changes are likely to occur within the normal duration of one component of a university degree course, i.e. about three terms. Studies of a longer duration, such as Perry's four-year study of the intellectual development of college students, are suitable for studying the really large-scale changes that students experience.

(b) **Intensive:** The study has to be intensive because of the range of information that is required. Since it must not isolate any part of the learning process, but take into consideration all aspects that emerge as relevant to each learning task studied, the students involved have to provide, repeatedly, accounts of all these various aspects. As full a description as possible is needed each time.

(c) **Case studies:** Because of the long-term and intensive form of the study, each student will have to be involved in regular hard-working sessions, and this will require a high degree of commitment on their part. This is easier to achieve and also to manage if the number of students is kept low. Each student must therefore be treated as a case-study and in these circumstances will be able to provide detailed and wide-ranging information about his experience of learning. Since part of the analysis would be concerned with comparisons between students, it is important that the number involved should be sufficiently high to allow this, probably of the order of 15 - 20.

The quality of data generated by such a study should be rich in information of the kind needed to investigate the main issues. Since it only covers a small
number of students, however, the full study should repeat the same procedure again on another set of students. As progressive definition of the parameters and descriptions involved takes place it may be possible to expand the research to study a larger number of students on a less intensive basis.

The most difficult part of the research design is to generate suitable techniques for gaining access to the various levels of the learning process being investigated. Interviews have provided an initial way of looking at this, but the method has a high wastage rate as it is often difficult to get students to describe their perceptions of learning in sufficient detail. More objective methods are also desirable if they can overcome the problems of interpretation by the researcher, and inaccurate perceptions by the students. How do we arrive at more detailed descriptions of orientation, strategy and executive style? In order to externalise the students' perceptions and cognitive activities at each stage, different kinds of techniques need to be developed. Some already exist that might be borrowed for the purpose.

(a) **Teachback.** The method of 'teachback' has proved useful in the present study. Students were asked to 'teach back' a particular topic, i.e. to give a spontaneous account of their understanding of the topic. Analysis of the protocols generated provided one way of gaining access to the kind of thinking they adopted towards the subject, i.e. the kind of executive style they used.

(b) **Stimulated recall.** This technique has been used to investigate students' responses to lectures, by aiding their recall of what they were thinking about at key points during the lecture. It is possible that this could be adapted to assist students in giving a detailed account of their strategy at key points in their execution of a learning task, and would therefore provide information on both strategy and executive style.
(c) **Repertory grids.** A more detailed analysis of students' perceptions of their orientation at particular times depends upon the investigator's ability to elicit accurate descriptions from the students. The 'repertory-grid' technique has been used as a way of helping students to articulate their own conceptual structures which they use, for example, to describe people or situations. It is possible that a technique of this kind could be adapted to elicit students' perceptions of their orientation towards their work.

A further elaboration of the model along these lines is a realistic possibility, therefore, if techniques such as these can be used in the study. The analysis developed for this data could also then be used to analyse the relevant teaching styles and learning tasks. The present study has analysed much of this data on the basis of existing descriptions and definitions, but the aim of a future study would be to develop further, more detailed descriptions. It is hoped that these further components will contribute to a fuller description of the learning process.

The present study has a number of implications for a future research study. It demonstrates the importance of the interaction between students' cognitive styles and strategies with their perceptions of the teaching-learning context. It provides a framework for future research, and in doing so suggests the directions this research might take, and how it might be done. Above all, it suggests that the learning process must be studied holistically.

The study also has something to say to teachers and students. It does not provide them with operational directives of what they should do, but this should probably not be the aim of educational research in any case. There is always a trade-off between one course of action and another*. What the researcher must do is to show how the various parameters relate to one another.

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* I am indebted to Malcolm Parlett for the clarification of this point in discussion.
what are the likely consequences of a particular action; he must provide an understanding of how the educational process operates that will inform the decisions of both teachers and students. The present study has suggested what some of the important parameters in the process are: the student's orientation to work - why he is doing it, his perception of the assessment and task requirements, his perceptions of the teaching, and his styles and strategies of learning. The study has also suggested some of the ways in which these parameters interact.

Students perceive the teaching as matching or mismatching the requirements of the learning tasks they are involved in. One source of difficulty is that students sometimes do not perceive a mismatch of this kind.

One way of describing this comparison is to use the operation/comprehension learning dichotomy where a mismatch may occur if, for example the teaching provides description building, but the task requires procedure building. In this case, the student's approach is important.

Those students who take an active, personal responsibility for their learning, by demanding of the teacher what they believe is necessary, may overcome problems of mismatch.

Many students do not do this, and it is probable that this is an approach which is acquired as the student matures during his university career.

Intrinsic orientation to work produces deep level approaches, regardless of the requirements of the task or the assessment. Some students' work and level of understanding may therefore not be recognised by the teacher.
Extrinsic orientation makes the nature of the assessment and task requirements important, and students perceive this as either productive, requiring some integration or synthesis on their part, or simply reproductive, requiring mainly memory work.

A number of aspects of the context are in the control of the teacher. If educational research can help him to understand how the students perceive these, and how they make use of them in determining their approach to learning, it may be possible for the teacher to improve the effectiveness of his teaching. Similarly, if students are aware of how they interact with the teaching-learning context, and of the other possibilities open to them, this improved understanding may be able to give them greater control over how they proceed through their university career.
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ADDENDA TO REFERENCES.


APPENDIX I

Letters from students in Stage B.
Dear Diana,

Thank you for the report you sent me in October; I really was quite interested in reading it — though slightly lary in replying, for which I apologize. The only misrepresentation which I would like to see amended is my definition of understanding the definition I give in the report is meant to represent the definition seemingly adopted by my department and therefore the definition I adopt for dealings with my dept. (i.e. exams) it certainly would not qualify as my personal definition.

Turning away from specifics I thought your assessment of myself to be quite accurate, but I don’t suppose that was difficult. One thing I should have mentioned during the interviews was the importance of general studies, in its present form it’s an absolute disaster considered by the majority as two extra free periods a week. But the idea is good, and the two essays a term at least enable an opportunity to express original thought without constant reference to text books, something rarely required in an engineering course. For general studies.

The model seemed to work successfully, and I was pleased to see that you realize how easy it would be to make virtually everyone fit the model had you a mind to do so. However I was left at the end of the report with the feeling that here was a price of research for research’s sake, with as yet little practical value.
Personally, for example, I would probably divided students in to two classes, those that are motivated and those that are not. Those that are motivated are not in desperate need of your assistance, those and may in the first instance be discounted. Of those that are not motivated - why are they not?... boredom, perhaps. These problems are basic and should be tackled first.

Also have you thought of you making any attempt to find common characteristics relating students with the same learning technique - family background for example, though I accept that factors liable to make research even more complex would probably be unwelcome.

In conclusion I'd just like to say that at present the report is slightly too theoretical for myself to truly appreciate. I'd like to see the completed report when with relevant conclusions if that is at all possible.

Hope you had a good Christmas, sorry again for the late reply.

yours sincerely

Ron

P.S.

My new home address is

Hatch Cottage
Phoenix Green
Hartley Wintney
Hants
Tel. 2193

Bad luck. Its still just a plot no. but my industrial gear address until August is?
Dear Diane,

Thank you for your letter of the 29.11.76. Congratulations, it is the most interesting thing I have read in a very long time. It actually made me think, which isn’t bad.

I read through the report and some time later, having had time to digest it, I come back
to writing this letter. Having started to read it through, it struck me that the best way of commenting on it was to annotate it. This I have duly done. Please, I must emphasize that the comments are purely personal, I apologize in advance for any offense, especially if my cheek is commenting on some of your English.

There is one other point that I didn't mention in the report and is valid: I did the 'Aid to Study' course
organised by Phil Hills in my first year (74-75). However, it transpired that most of the techniques they advocated I already used, at least a rudimentary form of them.

Something else struck me - aren't we on inarticulate latex? And were meant to be le crevasse le crevasse - God help the rest of the population!

I'm working for a firm called Engelhardt's at present and as part of a project I'll be doing in a week or
two I'll be coming up to the university so I'll see you then if you are around.

Yours sincerely

Stuart.
APPENDIX II

Letter from Professor J.S. Bruner.
Dear Miss Laurillard:

I really have very little to say about individual differences in strategies used by different subjects or even about characteristic strategies in different kinds of problems. On the last point, we do have a good deal to say, though, on how focus gambling results from a limitation of available instances, or how thematic material alters strategy. Our interest, really, was in characterizing ideal strategies and we came on these by what you quite properly guessed was a mix of looking at real behaviour and comparing it with logically idealized strategies. The scoring, essentially, is a discrepancy score between actual behaviour obtained and what would be required of an idealized subject following a strategy.

Does that help?

Sincerely,

[Signature]

Miss Diana Laurillard,
CUSC., I.E.T.,
University of Surrey,
Guildford,
Surrey GU2 5XH.
APPENDIX III

Letter from Professor J.D. Novak.
Ms. Diana Laurillard  
University of Surrey  
Institute for Educational Technology  
Guildford, Surrey  
ENGLAND

Dear Ms. Laurillard:

My apologies for the delay in answering your letter of August 17. The letter arrived when I was on a brief summer holiday, and then our classes commenced immediately upon returning. I am only now beginning to catch up on the work that accumulated in late summer.

Your results on the Thorsland's interview are not surprising, since we have obtained similar results on some of our own recent efforts to use this evaluation scheme. In spite of the fact that Thorsland's interviews appear to produce highly reliable results, and that a replication of his studies by one of my former students, Peter Castaldi, produced similar results, we have recently observed some difficulty in the responses of students on these interviews.

I read thru your interpretations of the results and I anticipate that your problem may be similar to what we have experienced. There seems to be considerable difficulty in classifying answers as either intuitive or analytic unless the students do reasonably well on the problems. We have found that some of the students enrolled in a first year college physics course have not performed well on this interview, in spite of the fact that the problems appear to be relatively simple. What your data and our data seem to suggest is that most students are operating without an integrated set of concepts, with lower order, less inclusive concepts meaningfully integrated with higher order, more inclusive concepts. This seems to be the result of essentially rote learning that is characteristic of much public school learning. The result is that students may have learned specific concepts (or specific formulas that apply to certain situations) but have failed to integrate these to a broader conceptual framework. The retention span for these low order concepts, while better than that for rotely memorized facts, seldom exceed six months unless it is integrated into a higher conceptual order. We are observing a somewhat similar phenomenon in a longitudinal study with elementary school children.

Our most recent efforts have involved the use of a "problem solving" test that is relatively subject matter neutral. We have used such problem solving measures both with college chemistry students and in our elementary science research. What we are finding is that good performers on these problem solving tests appear to be individuals who form hierarchically constructed frameworks. The result is not only long term retention of subordinate concepts, and an ability to use higher order concepts, but also substantially better ability in solving difficult subject matter problems. The theses involving this problem solving work were completed only this past summer and I do not have papers or summaries to send to you at this time.
I should like to keep in touch with you and would be happy to provide any counsel I can via the mails. May I suggest that you obtain a copy of my book, *A Theory of Education*, which will expand substantially on the theoretical framework from which our work derives. The London distributors for Cornell University Press is located at 2-4 Brook Street. I have enclosed a brochure describing the book.

Please give my best regards to Professor Elton. There is some possibility that I will be in England during the coming academic year and I should like very much to visit at Surrey.

Best wishes to you in your work.

Sincerely,

[Signature]

JOSEPH D. NOVAK
Professor of Science Education
Professor of Biological Sciences

JDN:sjd
encl
APPENDIX IV

Letter from Professor F. Marton.
Dear Diana,

I certainly did enjoy having your kind and most interesting letter. I am very happy with the fact that research of this kind is going on in Guildford.

I find it extremely interesting that you have worked with science students in two experiments of which in one they had to read one of their own textbooks. The fact is that a very similar research project is going on in Lancaster at the Department of Educational Research (Carmel College, Bailrigg, Lancaster LA1 4YL). Dai Hounsell and Paul Ramsden who are carrying out the studies have however made some findings which seem to be contradicted by the point you make in your letter. They have namely recently told me that, when investigating science students learning strategies they have come to the conclusion that either science students have a surface approach to a far greater extent than students of social sciences or the dimension of deep/surface approach cannot be applied to science students. Anyway, I think it would be very interesting if their results could be compared with yours.

Concerning the interview excerpts you send me: two of us independently came to exactly same conclusions as you. I think they are very clear cases; I would say they are prototypical.

Of course, I can`t possibly know whether these subjects have adopted a deep or a surface approach, I can only conclude that the excerpts seem to fit very well certain categories of description which we have arrived at previously. I am enclosing the translation of the judgement instructions we used in our first studies. The translation is not at all worked through. One of the two sets (process questions) was used for characterizing data from the learning experiment and the other set (macro-questions) was used in relation to the answers to interview questions concerning ordinary studies. This latter, kind of instructions doesn`t represent a very “mature” version. The categories 1.5, 1.7 and 2.4 clearly don`t belong to the same level of descriptions as the others and as regards 1.5 it seems doubtful what it belongs to.
We have used our categories in a disjunctive way; the subject’s way of functioning in the learning situation was characterized on the basis of any of the subcategories. This reflects, of course, our belief that the different subcategories are symptoms of the same underlying dichotomy (between paying attention primarily to content or paying attention primarily to words). We consider the latter above all as an artefact of the situation in which learning is based upon external demands. In this case attention easily becomes focussed on performance, on the desire to match the requirements. In this way the task becomes defined by the subjects as memorization of the text. One of the enclosed papers (Anders Fransson’s) which will appear soon in BJEP gives some evidence to this thesis; if content is relevant, if people aren’t anxious, if no stress is introduced by external demands deep approach will probably appear (almost by definition).

A am also sending you some other papers. A contribution from another member of our group (Lennart Svensson) to the BJEP symposium appearing in the fall issue together with Fransson’s paper, the preliminary translation of two chapters of our book which came out very recently in Swedish and two reports which you perhaps haven’t seen before. The one which Lars Owe and I have written together will appear in a revised version in Studies in higher education soon.

This is what I can do now, but I think the kind of research you are doing can’t be supported to a great extent by written documents. I think it would be very nice if you could spend some weeks of studies and discussions here in Sweden with our research group (Brian perhaps wouldn’t be entirely uninterested in a scandinavian visit either?). What do you think?

I have som plans for going to England next year, perhaps both in the spring and in September. We have some ideas of arranging a symposium in Lancaster (within or attached to a conference on research on higher education) on our commonkind of research (meaningful research on meaningful learning). Perhaps you and Vivian (if she is still in this field) could attend such a symposium?
I really look forward to hearing from you again.

Best wishes to Vivian, Lewis, Brian etc.

Sincerely yours

Ference Marton

Enclosure
APPENDIX V

Spy Ring History Test and correspondence.
Background Data

The following notes give brief background information about the agents and the countries in which they operate:

Ruritania: A rich country, with grassland and fertile valleys, some industrial development along the river Thum, and the lake into which it flows. A fairly contented people, governed by a liberal, paternalistic dictatorship.

Transylvania: Hilly, with dense forests, rich deposits of tin, iron, copper and coal. Sullen, puritanical people and a stable totalitarian "socialist" regime. The capital city, Grosnantz, is situated on a tributary of the Thum, and is famed for its ancient and beautiful bridges across the stream.

Olympia: Bleak mountainous, some peaks are permanently snow covered. Independently minded peoples organised in clans, fiercely loyal to their traditional rulers. In contrast, its capital, Faldig, is a centre of learning, banking and the arts. Recent growth of tourism (ski-ing, especially), with resorts in the mountainous region, at the source of the river Thum.

Ruritania, Transylvania and Olympia are geographically adjacent and form a regional unit. The government found it useful to keep an eye upon the tensions which build up and subsided between the three countries, due to differing political regimes, natural resources, and economic development, even though the borders between the three countries remained unchanged. Partial, but accurate, records are available regarding the espionage which took place for a period of three years from 1985 to 1987.

Five spies were assigned to the whole region, Ajax, Byron, Caesar, Dryden and Euclid. Each agent lived and worked in one of the three countries: Transylvania, Olympia and Ruritania.

The spies were instructed to set up and maintain a communication network, so that the information they collected could be pooled. Pooling their information in this way helped them individually to build up a better picture of what was happening in the region, but could also lead to delays in sending messages and the possibility of introducing false information. Agents in the same country are unlikely to falsify information passed between them, as it would be detected too easily, so that all "within nation" messages are true.
Communication (in espionage) is a "costly" business, for the existence of each communication channel between one agent and another agent, increases the chance of its detection. This risk is especially high when messages are sent from an agent in one country to an agent in another. Because of this risk no spy can send a message to another spy if it must cross more than one geographical boundary. Due to the regular fluctuations in tension existing in the region, the communication network was modified from year to year, and the number of links between spies (i.e. direct communication channels from one spy to another) also changed. The smallest number of links in any year was 5 and the greatest in any year was 7.

During the whole period each spy was able to receive messages from at least one other spy, and to send messages to at least one other spy. The agents are known to have played different roles inside the network. One of them acted as a messenger, receiving messages and passing them on, but never originating messages. Two agents could originate messages, as well as pass them on, while two other agents must accumulate at least two messages from other spies before being able to transmit a message. These roles did not change during the period of 1985 to 1987.

The records for the years 1935 to 1937 are available in the form of lists of 8 messages, sent from one agent to another agent, each one showing the country occupied by the spy in question, and indicated by (R), (T), or (O), after the spy's name.

There is one list for each year, each list shows the messages in the order in which they were sent during that year. You can use this information to work out what the spy ring network would look like, (as a graph or network, and the geographical location of the spies), for each of the years. From the list you could also work out which spies occupied which role. The opposite is not true of the spy ring networks, if you have a graph showing all the possible ways of sending a message from one spy to another spy for each year, you cannot use it to work out the actual messages sent nor the role of the spies in the network; but the use of the network does help in remembering where the spies are, and how the ways in which they had to communicate changed each year.
Something is also known about the agents themselves, namely, the following facts:

Ajax: Early forties, multi-lingual adventurer, athletic, classics scholar.
Cover: traveller in fertilizers; genuinely employed by Ruritanian Chemical Company.

Byron: Dour Scot, age 35, speciality organic chemistry, drugs, plastics.
Cover: Laboratory technician in plastics research establishment owned by same chemical company that employs Ajax.

Caesar: Fifties, placid pipe-smoker, engineer, systems analyst.
Cover: Mining engineer, frequently moves from pit to pit.
Plays role of vigorous, hard-line party member.

Dryden: Hard, swarthy featured, ex-chess champion, the youngest.
Cover: Commissar in security division of Ministry for Social Welfare; chiefly employed for exposing trouble-makers in the mining industries.

Euclid: Early sixties, urbane. Mathematician, student of the occult.
Cover: Spiritualist and astrologer patronised by the social elite seeking advice on commercial, political and personal problems.
location of the transmitter and the receiver is indicated but the message content is not known. Although many more than 8 messages passed between Ajax, Byron, Caesar, Dryden and Euclid each year, each list is a sample of 8 messages that show all the possible ways spies had of communicating with each other within their spy ring. If, in one year, two spies never communicate in the list of messages you are shown, this is because such a path for messages is impossible for political or social reasons. Each message shows a possible path that has been used at least once in that year, but some lists may show a path which has been used more often.

By learning these lists you could begin to build up a picture of the spy ring organisation as it existed in each year, but in order to build up a picture of the spy ring over all the years you need also to learn other things. One of these is the fact that the spies all have a specific role in the organisation, and some spies are more important in the network than others. There are three kinds of roles spies can play, these are:

- **Originator** - a spy who can send a message to another spy, without having to have anything other than fresh information to send. That is, he doesn't have to hear from any other spy before he begins to send information, although he can also pass on messages received from one or more other spies as well as originating material.
- **Receiver/transmitter** - a spy who can only transmit a message he has received, but he may or may not delay his transmission.
- **Receiver/accumulator** - a spy who only transmits a message after he has received at least two messages from other spies, he may do this immediately or he may wait, but he cannot transmit until he has accumulated at least two messages.

The spies never change role during their activities as part of the spy ring. The ways in which messages have to be passed can change from year to year, as the counter intelligence agents uncover message routes, but the spies' functions never change.

You can obtain a great deal of information about the spy ring by learning the sequence of messages. You could learn them by rote and may do so. But you will probably find it more efficient and easier to learn the rules which the lists contain so that you could produce simple messages according to these rules and make guesses if you notice the following facts.

First of all, the spies are always in the same country, so that if a spy begins by being in Ruritania, he will always be in Ruritania. He may send a message out of Ruritania, but he himself will not leave the country.

Next, a message sent by one spy and received by another spy cannot cross more than one geographical boundary at a time.
Remember, you can use directed graphs to see all the possible ways the spies could communicate for each year, but you need the lists to find out which role a spy plays in the network. You can work out the graph from the list, and you can work out a list from the graph, but the graph does not tell you on its own, what roles the spies occupy. If you have discovered their roles by reasoning about the lists and know the graph for a year, then you can work out a representative list of 8 or more (as many as you like) possible transactions which would be just as good a sample as the 8 message samples given in the lists.

Finally, for various reasons, the number of communication links between spies will never be less than 5 or more than 7 in any year.

Knowing this and given the intelligent interpretation of the message lists combined with other information (notably the graphs, but there are other cues), should also allow you to make reasonable predictions.

1. The three countries are close together: show, by making a map, where their common boundaries are and place the spies in the country in which each one is working.
1938. Complete records for that year do not exist, but we do know that the pattern of the spy ring changed again in 1938. The spies in the spy ring still obeyed the same rules as in 1935, 1936 and 1937 so that the new spy ring pattern must have been similar to those of the previous years. You can use the information you have about those years to help you make a possible pattern for the spy ring in 1938. Please draw a picture of what you think the spy ring pattern was like in 1938.

\[ D(T) \rightarrow E(C) \]
\[ E(C) \rightarrow C(T) \]
\[ B(R) \rightarrow A(R) \]
\[ U(T) \rightarrow C(T) \]
\[ I'(O) \rightarrow C(F) \]
\[ E(R) \rightarrow A(R) \]
\[ E(C) \rightarrow C(T) \]
\[ A(R) \rightarrow B(R) \]

3. Which kind of information did you chiefly use in making your prediction. For each question tick a number on the 1 to 5 scale as an indication of your reliance upon each kind (5 means you relied a great deal, while 1 means you did not use this type of information).

(a) By seeing patterns or symmetries in the spy rings and using them to work out the type of patterns which would occur later.

\[ \begin{array}{ccccc}
1 & 2 & 3 & 4 & 5 \\
\end{array} \]

(b) Using information about the economic cultural or political state of the countries and their international relations.

\[ \begin{array}{ccccc}
1 & 2 & 3 & 4 & 5 \\
\end{array} \]

(c) "Cost" of (or risk involved in) sending messages.

\[ \begin{array}{ccccc}
1 & 2 & 3 & 4 & 5 \\
\end{array} \]

(d) "Logic" (the rules governing spies in the networks and the messages they can send).

\[ \begin{array}{ccccc}
1 & 2 & 3 & 4 & 5 \\
\end{array} \]
Please attempt the following questions, responding by ticking true or false, or as otherwise indicated. In addition, please tick a number, as before, to indicate your confidence in your answer. (5 means that you are certain, while 1 means that you are very unsure.)

(a) A spy is always in a position to receive messages from one or more other spies and to send messages to one or more other spies.
   True   False   (tick one and only one). How sure are you?
   ✓   1 2 3 4 5

(b) Any spy located in one country is able to receive messages either directly or indirectly from a spy who is in a different country.
   True   False   (tick one and only one). How sure are you?
   ✓   1 2 3 4 5

(c) A particular transmission link between a pair of spies never crosses more than one geographical boundary.
   True   False   (tick one and only one). How sure are you?
   ✓   1 2 3 4 5

(d) During different periods the spies in different countries are isolated.
   True   False   (tick one and only one). How sure are you?
   ✓   1 2 3 4 5

(e) One country, which has a border crossing to two other countries, is never isolated in this way.
   True   False   (tick one and only one). How sure are you?
   ✓   1 2 3 4 5
Tick one or more.

Ajax Byron Caesar Dryden Euclid

How sure are you that you are right? 1 2 3 4 5

(g) Which spy never originates messages (he only passes them on)?

Ajax Byron Caesar Dryden Euclid

How sure are you that you are right? 1 2 3 4 5

(h) Which spies both originate and pass on messages?

Ajax Byron Caesar Dryden Euclid

How sure are you that you are right? 1 2 3 4 5

(i) Which spy usually has the greatest control over the network (for example, is able to falsify messages)

Ajax Byron Caesar Dryden Euclid

How sure are you that you are right? 1 2 3 4 5

(j) Are there any year(s) in which the spy with greatest control loses this power?

1985 1986 1987

How sure are you that you are right? 1 2 3 4 5

You will be asked in Q6 and Q7 to recall the transactions of the spies and of the changes in the network.

It may help you to know that (a), (b), (c), (d) and (e) are all true.

It may also help to recall that Ajax and Byron operate in Ruritania, Caesar and Dryden in Transylvania, and only Euclid in Olympia; that (f) Ajax and Caesar accumulate messages before transmitting, that (g) Euclid never originates messages, and that (h) Dryden and Byron both originate and pass on messages.

You may answer Question 6 and Question 7 in either order but please indicate the order by entering 1st or 2nd in the corner box at the top of the sheet. Question 6 is about the Spy Ring network and should be answered using directed graphs, and Question 7 is about the transactions of messages which took place, so that you use the list format for this question.
7. Please construct representative sequences of messages that could have been sent in the year 1985, 1986, 1987, and your prediction for 1988 (spies and countries). Any number of transactions can be given as representative (a practical maximum of 16 is suggested, but 8 is a minimum). Mark the year on each sequence.

**1985 typical transactions**

- $D(T) \rightarrow E(0)$
- $E(0) \rightarrow B(R)$
- $B(R) \rightarrow A(R)$
- $D(R) \rightarrow B(R)$
- $B(R) \rightarrow A(R)$
- $A(R) \rightarrow E(C)$
- $0^*(0) \rightarrow C(1)$
- $C(1) \rightarrow D(R)$

**1986 typical transactions**

- $D(T) \rightarrow B(R)$
- $E(C) \rightarrow C(T)$
- $B(R) \rightarrow A(R)$
- $B(R) \rightarrow A(R)$
- $A(R) \rightarrow E(C)$
- $A(R) \rightarrow D(R)$
- $H(R) \rightarrow D(R)$
5. Please try to answer these questions as briefly as possible. Please tick a number to indicate your confidence in each answer as in previous questions. 5 means certain, 1 means very unsure.

(a) Who was the oldest spy? Tick one.
   Ajax Byron Caesar Eryien Euclid
   How sure are you that you are right? 
   \[ \begin{array}{lllll} 1 & 2 & 3 & 4 & 5 \end{array} \]

(b) Which spy smoked a pipe? Tick one.
   Ajax Byron Caesar Eryien Euclid
   How sure are you that you are right? 
   \[ \begin{array}{lllll} 1 & 2 & 3 & 4 & 5 \end{array} \]

(c) Where was Byron located? Tick one.
   Ruritania Transylvania Olympia
   How sure are you that you are right? 
   \[ \begin{array}{lllll} 1 & 2 & 3 & 4 & 5 \end{array} \]

(d) Which spy was a mathematician and student of the occult? Tick one.
   Ajax Byron Caesar Eryien Euclid
   How sure are you that you are right? 
   \[ \begin{array}{lllll} 1 & 2 & 3 & 4 & 5 \end{array} \]

(e) Which is the most mountainous country? Tick one.
   Ruritania Transylvania Olympia
   How sure are you that you are right? 
   \[ \begin{array}{lllll} 1 & 2 & 3 & 4 & 5 \end{array} \]

Continuei ............
Spy Ring History Test Form III: Scoring Procedure

Q1. (a) If Ajax in Ruritania, score 1 otherwise 0.
If Byron in Ruritania, score 1 otherwise 0.
If Caesar in Transylvania, score 1 otherwise 0.
If Dryden in Transylvania, score 1 otherwise 0.
If Euclid in Olympia, score 1 otherwise 0.

Sum the scores and divide by 5. Assign the resultant value to category R1.

(b) Ruritania and Olympia must have common border.
Transylvania and Olympia must have common border.
Ruritania and Transylvania must have no common border.

If the above conditions hold, score 1 otherwise 0.
Assign this value to category X1.

Q2. Compare the subject's predicted graph for 1988 with figures I - VI below.
Isomorphism requires correspondence of named nodes, arcs and arc directions.

Assign scores to categories Vz and Xz as follows:

<table>
<thead>
<tr>
<th>Response isomorphic to figure</th>
<th>Vz</th>
<th>Xz</th>
</tr>
</thead>
<tbody>
<tr>
<td>figure I</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>figure II</td>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>figure V or VI</td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>figure III or IV</td>
<td>0.25</td>
<td>0.5</td>
</tr>
</tbody>
</table>

If C and D are connected in some way but not connected to any other node:
* 0 0.25

Any other response
* 0 0
Q3. For each item, assign scores to the categories as listed below. Scores are derived from the 1 - 5 confidence estimation scales as follows: 1 = 0, 2 = 0.25, 3 = 0.5, 4 = 0.75, 5 = 1.0

Value of item (a) assigned to category X 3
" " " (b) " " " S 3
" " " (c) " " " Y 3
" " " (d) " " " U3
Q4. For each item, assign scores to the categories as listed below. Scores are derived from the 1 - 5 confidence estimation scales as follows: 1 = 0, 2 = 0.25, 3 = 0.5, 4 = 0.75, 5 = 1.0.

Value of item (a) assigned to category S4

\[
\begin{align*}
\frac{1}{2} & \quad " (b) " \quad X4 \\
\frac{1}{2} & \quad " (c) " \quad X4 \\
" \quad (d) " \quad T4 \\
" \quad (e) " \quad U4 \\
\end{align*}
\]

Q5. For each item which the subject has answered correctly, assign scores to categories as listed below. Scores are derived from the 1 - 5 confidence estimation scales as follows: 1 = 0, 2 = 0.25, 3 = 0.5, 4 = 0.75, 5 = 1.

a) If TRUE, assign score to category U
b) If TRUE " U
c) If TRUE " U
d) If TRUE " X
e) If TRUE " Y5
f) If AJAX and CAESAR " U
g) If EUCLID " U
h) If BYRON and DRYDEN " U
i) If EUCLID " X
j) If 1986 " X

Note: Sum scores for category U (items a, b, c, f, g, h), divide by 6 and assign to category U5 (see table at end of scoring procedure).
Sum scores for category X (items d, i and j), divide by 3 and assign to category X5. (see table).

Q6. Discard any response graphs which do not have five correctly labelled nodes. Ignore any graph for 1988 (the prediction year).
a) First, disregarding arc directions, match each response graph against the undirected forms of the graphs presented for learning, as shown below:

```
1985
A  C
|  |
B  E

1986
A  C
|  |
B  E

1987
A  C
|  |
B  E
```

Score 1 for isomorphism, otherwise 0, for each year. Assign the resultant score to category X6.

b) For each year derive a score (F) by counting the number of correct arcs (this time taking into account the direction of arcs). Divide the number of correct arcs by the total number of arcs drawn for the year in question. Form a table of values for F, thus:

```
1985   1986   1987
F
```

Sum F values. Assign the resultant score to category Y6.

c) Score 1 for each response graph which has country boundaries correctly shown. Divide total score for this by 3 and assign value to S6.
Q7. Form a table of numbers $E$

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>1986</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$E$ is given by finding the number of correct lines in each year and dividing by the total number of lines for that year. A correct line is one which shows a connection between two spies which is valid for the year in question; and valid also with regard to direction and correct placing in sequence. Thus:

Ajax and Caesar are distinguished by the fact that before they may transmit a message, 2 messages must have been received. After receipt of 2 messages, each transmits without delay.

Euclid can only pass on a message received earlier in the sequence. There may or may not be a delay.

Byron and Dryden are able both to originate messages and to pass on messages received earlier.

Sum $E$ values. Assign the resultant score to category $T7$.

Next consider the constructed transactions for the prediction year (1988) and by the same criteria establish a score to be assigned to category $V7$.

Q8. For each of the items a–h for which the subject has given the correct answer, derive a score from the 1–5 confidence estimation scale as follows: $1 = 0, 2 = 0.25, 3 = 0.5, 4 = 0.75, 5 = 1.0$.

Sum the scores obtained and divide by 8. Assign the resultant value to category $R8$. Correct answers are as follows:

(a) EUCLID
(b) CAESAR
(c) RURITANIA
(d) EUCLID
(e) OLYMPIA
(f) TRANSYLVANIA
(g) RURITANIA
(h) OLYMPIA
Table Maximum scores under each category for each question plus an additional V weighting (bottom row of table) given by $V = Y_6 \times T_7$

The detailed categories are for a fine analysis that is still being explored. Summary categories are as follows:

1. Neutral score = $R$ (maximum = 2)
2. Operation learning score = $U + T$ (maximum = 7)
3. Comprehension learning score = $X + Y + S$ (maximum = 16)
4. Versatility score = $V$ (maximum = 3)

Summary scores can be expressed as a percentage of the maximum for each summary category.
The details of my use of this test are outlined below. The first session with four students was administered by Mrs. E. Pask, during which I took notes and thereafter was able to follow the same procedure myself.

Number of students: 31  In groups of 1 - 4

Method: Same as that demonstrated by E. Pask except that the first two trial networks and background information were administered to the group and the rest was administered individually. This was possible with small groups, and lessened somewhat the tension of a competitive atmosphere in the groups. The first four students were interviewed after the test about how they had worked through it. On the basis of these interviews a questionnaire was designed which was administered to every student after taking the test.

The results were scored according to the original scoring system and are reproduced in Table 1. In column 5, 0 and C scores are compared to highlight those students whose scores differed by more than 20% (a figure quoted to me in subsequent discussions with Elizabeth Pask as demonstrating bias one way or the other). Column 6 highlights those students who scored high (in the upper quartile) and low (in the lower quartile) on versatility. Column 7 highlights those students who scored high on both 0 and C and low on both 0 and C (again upper and lower quartiles).

These scores demonstrate several points:

Only two students who showed marked bias were particularly low on versatility scores.

Only two students who scored high on both 0 and C also scored high on versatility.

Five of the students who scored low on versatility also scored low on both 0 and C.

These points suggested to me that the V scores did not correlate with the similarity between 0 and C scores, i.e. versatility does not measure the ability to use both operation and comprehension learning equally. This was accounted for to some extent in discussion with the originators who explained that the versatility score is designed
to measure the extent to which the student is able to use both O and C to go beyond the information given and construct new knowledge. In addition to this, the correlation between low V and low on both O and C suggested that poor performance throughout the test might be due to the common factor of failure of memory.

Bearing these points in mind, I went through the scoring of the test to rescore the questions according to those that involved straight recall of information given in the text and the networks (M scores), and those that required the student to make some kind of deduction (P scores, for productive thinking). For example, question 5f, "which spies accumulate information?" requires the student to use his knowledge of rules, and is thus 'productive', whereas question 5a, "A spy is always in a position to receive messages from one or more other spies and to send messages to one or more other spies. True or False?" requires straightforward recall of the information given at the start of the test and is thus 'memory'. Full details of this rescoring are given in the appendix. The results of this rescoring are given in Table 1, and plotted in Fig. 1. From the plot of the data, it can be seen that, as expected, those students with low M scores also have low P scores, whereas those with high M scores have a range of P scores from low to high. In order to obtain over 24% on the P scores, the student must obtain more than 64% on the M scores. It seems from this, therefore, that the student's ability to use information productively is highly dependent on his ability to remember the necessary information.

The interpretation of the results of this test has to be done with care, especially as the test itself, and the scoring procedure, is still undergoing development. It would be unwise to conclude from the test results alone that, for example, students who had low P and high M scores were, in fact, immature learners because they showed an inability to use the information they had. At this stage of its development, the test should be supplemented by additional information on how the students perceived it. After the test session, each student was asked to write down his answer to the question:

"The aim of the exercise was to use your knowledge of the rules of the networks, and the way they operated in 1985, 1986 and 1987, to predict how they would operate in 1988. Did you realise this was the aim? How did your attempts to learn the data relate to the aim? Please explain why you did what you did".

The written replies showed that all the students found aspects of the test difficult to understand, some questions ambiguous, and too little time to do what they felt was
necessary to achieve the aim of prediction. This was true even of the high M, high P scorers:

"Personally I felt there was not enough information for me to be able to generate a network for 1988. I would have needed lots more information before I could have felt happy about my prediction"

Charlotte

"In the last section ..... a derivation from raw data could have produced more accurate results, but this was not attempted because of partially vague recall and time pressure"

Roy

A particular problem that was mentioned by all the low P scorers was seeing how the prediction might be made at all. These students found it difficult to see any obvious relationship between the spy rings in the three years and could not find any basis on which to make a prediction. This explains how high M scorers could still be low P scorers:

"I did realise this was the aim, but my methods didn't relate to it. I couldn't see why you should be able to predict - I just waffled"

Jack

"I did not grasp what kind of deductions or rules I was supposed to make from the previous years' data lists. Hence really all I could do was to learn the lists and graphs without any particular bias to one aspect or another"

Sheila

It could be argued, perhaps, that differences in P scores reflect the students' ability to cope with a highly demanding task and to work out what was being asked of them. However, even the high P scorers mentioned some uncertainty about those questions where they were asked to go beyond the information given:

"More time would be required to 'mull things over' before deductions could be made with any degree of certainty"

Bill

"I found it quite hard to realise what was required of me after storing the information"

Charlotte

"In the section where their roles were asked for, I did not fully analyse the data to get the roles as I had lost complete recall"

Roy
Comments like this suggest that some good predictions were not fully thought-out deductions, as they may appear in the results.

A full interpretation of these test results is therefore difficult for the following reasons:-

1. The 'versatility' score neither reflects lack of bias towards operation or comprehension learning, nor coincides with exactly those questions that test the ability to 'go beyond the information given'.

2. A rescoring which compares memory with deductive ability shows that the latter is only possible when memory is good.

3. From questionnaire data it seems that the test is so complex, and time pressure so great, that many students may not have the opportunity to exhibit their deductive ability.

For these reasons it would be unwise to make any predictions about the students' normal learning capabilities on the basis of either V or P scores.

As was discussed earlier, most students had similar O and C scores. There is no theoretical reason why the two scores should be related, and Pask has shown, using Spearman's rank correlation coefficient, that for at least one study they are not (Pask 1977). The scores here, using the same test, produce a $R_s$ of 0.39 which is significant at the 0.05 level. This unusually high correlation is perhaps not so surprising among university students who may be expected to develop both types of learning in accordance with their status as the most successful and efficient learners of their age-group.

To summarise: I feel that the test in its present form needs very careful interpretation. I would be reluctant to make deductions about students' capacity to use both operation and comprehension learning on the basis of it. However, it is still undergoing development and is clearly capable of being an extremely useful tool for the study of student learning. It is its complexity which creates the difficulties for students to demonstrate their true ability, but it is precisely this complexity that makes it so valuable, and so far in advance of any other tools of its kind. I should therefore like to see the development of the test move towards making things clearer to the student, and perhaps a re-analysis of the scoring system, rather than towards reducing its complexity.

Acknowledgements

I should like to express my thanks to Gordon Pask, Elizabeth Pask, Bernard Scott and David Ensor in helping me to run the test.
APPENDIX.

Re-scoring

M scores = $R + V_1 + \frac{U_5}{3}(5a + 5c) + X6 + Y6 + T7$

$P$ scores = $V2 + X5 + Y5 + \frac{2U5}{3}(5b + 5d + 5e + 5f) + V7 + X1$

These refer to questions as follows:

$M = 1a + 5a + 6a + 6b + 7(1985-7) + 8$

$P = 2 + 5d + 5e + 5f + 5g + 5h + 5i + 5j + 7(1988) + 1b + 5b$

M scores require recall of information given in the background information, the preface and the networks.

P scores require production of new information.
15 March 1978

Dear Diana

Thank you for your letter and the report, which is very interesting and helpful.

Some comments and suggestions, chiefly from Bernard Scott, so far, are attached to this note (I am sending a copy to Prof Entwistle since I had an opportunity to look at your report together, admittedly rather briefly, since it came in the morning post and we had a fairly heavy schedule; also, as you know, I am not good at mornings and I doubt if Noel either).

Since returning home we have analysed the data for the 29 tabulated students to obtain the following results:

\[ N = 29 \]

in component correlations:

\[
\begin{align*}
N \text{ v. } O & \quad 0.23 \\
N \text{ v. } C & \quad 0.28 \\
N \text{ v. } V & \quad 0.31 * \\
O \text{ v. } C & \quad 0.57 \n
\quad & \\
O \text{ v. } V & \quad 0.61 \| \\
O \text{ v. } V & \quad 0.58 \| \\
((O - C) \quad \frac{(O + C)}{2}) \quad \text{v. } N & \quad -0.17 \\
\text{ditto v. } V & \quad -0.33 * \\
\end{align*}
\]

ana Laurillard's M score vs. her P score \( 0.60 \| \)

significant at 5\% point \( (p < 0.05) \)

significant at 1\% point \( (p < 0.01) \)
The score index \((O - C) / \frac{1}{2} (O + C)\) is an indication devised by Dave Ensor to mark bias towards operation or comprehension learning. It should (and, fortunately it does) correlate negatively with versatility; suggesting that the V component has some degree of independence.

Basically we like your M and P scores, though Bernard, who has been through the marking system at greater leisure, has some reservations. We surely also agree with your recommendations, in principle, regarding development of the test and will be in touch. My own reservations about the P score is that even if the points made by Bernard (as below) are dealt with, you seem to be equating "Productive Thinking" (presumably considered in Wertheimer's sense of the phrase) with deductive and direct kinds of inference; in fact, at one point you use "Deductive Capability". This is definitely not saying that the P score (adjusted, I think) is pointless; quite the contrary, it behaves as it should do if the test is working, psychologically. But I feel we need an open ended "Productive Thinking" core as well, distinct either from P or V (the latter is chiefly a measure of "going beyond", or "extrapolating rationally"; perhaps Liam Hudson's riginality!)

These, and other development possibilities, are better discussed than written about. This letter is just a beginning to (I hope) a continuing dialogue for improving this and the companion "matched" test, the "Smugglers test". Thus, I am adding Bernard's detailed comments, together with some quests, in view of the fact that we currently score on a set of components \(U, X, Y\) as well as \(O, V, N, C\) (the main components) but need the raw data for this purpose, so that we can update our test performance records with your sample.

Bernard says (and I am taking the liberty of quoting him in note rm):

The distinction between M and P is basically that M refers to recall of background and preface information, plus recall of lists and networks, and refers to inference of which spy has which role (role definitions being given) and prediction of list and network for 1988. Some of the questions signated M type or P type do not obviously fit the category they have been assigned to.

Score Questions:

1a  - information is in background data.

1b  - location of borders is not explicitly stated; this should be a P type. Inferred from break in 1986 (see also 5(b), 5(d), 5(e), 5(j)).

5(a) - background data.

5(b) - not explicitly stated; is inferred from break in 1986; hence should be P type. The question is equivalent to question 5(d) which is a P type.
Score Questions (continued)

5(c) - preface.
6(a) - recall of graphs - active encoding required.
6(b) -
7 - recall of lists - active encoding required; knowledge of roles very efficient for encoding.
(1985-7)
8 - background data.

Score Questions

2 - prediction of graph.
5(d) - inferred from break in 1986 (see 5(b)).
5(e) - inferred from break in 1986 (see 1(b)).
(f), 5(g) - infer which spy has which role.
(h)
5(i) - inferred.
5(j) - inferred from break in 1986 (as 5(b) and 1(b)).
7 1988

Changes in test question format and scoring

The current version of test has slight modifications to questions and further modifications to scoring procedure. Miss Laurillard's data could be rescored, though I don't think overall relationships between main categories would be significantly effected.

I agree that high O and C correlation (which is in fact higher than cited), is atypical when compared with mixed specialist 6th formers; Queensgate and AA data. Her hypothesis of sample bias is worth investigating - we are incorporating a comparison of Science/Arts specialists in our current study of 6th formers.

May we at least have the raw scores in tabular form for examination of subcategories. Otherwise rescoring requires booklets since now derive distinct T and U scores from them (which is preferable if you can send us copies of the response booklets)."
continued . . .

The last point is really important. If you have raw score booklets it is probably easier for us to run them on the scoring program.

I am also sending a copy of the BASIC listing for the computer administered "Spy Ring History Test". It has been written to use the standard "Alpha Numeric" character set rather than a vector drawing display.

With very best wishes.

Yours sincerely

Gordon Pask

Prof N Entwistle
Elizabeth Pask
Bernard Scott
GP file
LB file
APPENDIX VI

Notes on Close-Packed Hexagonal Structures.
APPENDIX VI. Students were asked to work through problems, referring to the diagram.
APPENDIX VII

Notes on Equilibrium Diagrams.
Alloy 1  On cooling from the liquid region an A rich solid α of composition .......... starts to crystallise out at temperature .......... If cooling follows equilibrium, then the alloy will become completely solid at temperature .......... Since cooling is invariably non-equilibrium, then solidification will be complete at a lower/higher temperature than this.

Alloy 2  This alloy initially cools in a similar way to alloy 1 to give the solid α. However, the solid α starts to precipitate the B rich β phase at temperature .......... On further cooling the solid α becomes richer/poorer in A by precipitating β. Finally at room temperature this alloy consists of a mixture of α of composition .......... and β of composition .........., the proportions of α to β being ..........
thus at the peritectic temperature some/all of the α must have reacted with some/all of the liquid to give β and the excess α /liquid. The amounts of α and liquid in this alloy at the peritectic temperature are .......... α and .......... liquid which can be compared with the amounts of α and liquid required for the peritectic reaction to go to completion, namely .......... α and .......... liquid.

Alloy 5 Describe carefully the solidification sequence for this alloy.
Fig. 5.3 *Equilibrium Diagram referred to by students.*