AN INVESTIGATION INTO THE LEARNING STRATEGIES AND STYLES OF ENGINEERING UNDERGRADUATES

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To seek and find a method
by which the teachers teach less
and the learners learn more.

Comenius (1592-1670)

Abstract

The aim of the research was to investigate learning methods in engineering education. The main objective was to study and obtain an understanding of the interactions among learning strategies, learning styles and student performance on various assessments. As part of this study it was proposed that a learning model be developed and incorporated into a knowledge based system.

Learning models have been investigated and a learning model is proposed for discussion. The model includes learning aims, assessment of existing knowledge, the experiential learning cycle and post tests with feedback. Elements on learning strategies and styles are also incorporated within the model. A learning style assessment module for the knowledge based system has been developed and is described.

The learning strategies and learning styles of a representative sample of engineering students have been investigated. The sample consists of 125 students from the BEng Honours courses in Mechanical and in Integrated Engineering. These strategy and style results are presented and are compared with previous published data. Correlations between learning strategies and motives are presented and discussed. Generally these correlations show that there are positive relationships within the surface and deep learning domains with weaker correlations between achieving strategies and motives. The study of the four learning styles of activist, theorist, reflector and pragmatist shows that there is no relationship between the styles, i.e. each style measures an independent characteristic of the learner. Based on the Honey and Mumford Learning Styles Questionnaire and the Biggs Study Process Questionnaire, the study indicates that learning styles are different to learning approaches (strategies and motives).

Relationships among student strategies, styles and student performance are reported. The research does not indicate any strong correlations between learning strategy or motive and assessment marks. However a correlation between the theorist learning style scores and marks was observed. It appears that this theorist style is most likely to be successful in engineering degree courses at Nottingham Polytechnic. A comparison between study modes indicates that part-time mature students have higher deep learning approaches than full-time students. This is matched by higher part-time student marks.

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Chapter 1:

Introduction

In one sense words are our masters,
or communication would be impossible.
In another we are the masters;
otherwise there could be no poetry

Roger W Holmes

Chapter 1 - Introduction

Aims and objectives

One of the current trends in education is towards student centred learning techniques, not just to develop effective study skills, but also to develop the personal skills that are considered desirable for a future career. These personal skills are extensive, however some of the more important areas can be summarised as:

- initiative and independence
- problem solving and logical reasoning
- research of material
- self learning
- communication; verbal and written.

The importance of these personal skills is recognised within the Department of Mechanical Engineering at Nottingham Polytechnic where there is a strong interest in developing effective student centred learning methods. A number of initiatives have been introduced within the department to enhance the educational experience for its students. The research reported in this thesis, has been carried out within this framework and as part of the on-going development of courses and the associated curriculum planning. The aim of the research is to provide an understanding of effective study methods for engineering students. In particular, the research includes a study of the learning strategies and learning styles of engineering students, relating these to student performance on a variety of assessments.

As an engineer working in education the author has an interest in the way in which students learn and in teaching methods which can be used to improve the learning experience for students. The research has stemmed from this personal interest in study methods and the educational work initiated in the Department of Mechanical Engineering. As well as the personal reasons for carrying out the research there is a need to understand how courses and the corresponding curriculum can be developed so that the above personal skills can be integrated with the technical and analytical aspects of a course. Understanding student learning is central to course development and also provides a means of helping students to assess their individual study methods in order to develop more effective learning techniques.

In order to fulfil the aims of the research a number of specific objectives have to be met. These objectives are related to the learning strategies and learning styles of engineering students and the relationships with student performance on a course. The research objectives, listed below, are to:

determine the learning strategies and learning styles of a representative sample of second year engineering degree students;

compare these strategies and styles with published data from previous studies by other researchers;

confirm the previously determined relationships among learning strategies and learning motives;

investigate the relationships among different learning styles and between learning strategy and learning style;

investigate the relationships among learning strategies and learning styles of students with their performance on continuously assessed work and examinations;

compare the learning strategies and learning styles of full-time and part-time students.

Following from these research aims and objectives are a number of hypotheses as listed below:

learning strategies adopted by students are directly related to their motives;

learning strategies of students are independent of and hence different from their learning styles;

adopting a deep or achieving approach to learning will result in a better understanding of a subject which should lead to better results on assessments;

learning styles have a direct bearing on student learning and certain styles are suited to engineering education;

students with two or more learning style preferences achieve better results than those students with a strong preference for just one style;

part-time engineering students have greater motivation than full-time engineering students and this leads to better results.

Learning style and strategy

Learning styles are concerned with a student's preferred way of learning and are part of the personality of the learner. A style can be developed but it is essentially a characteristic of the student. Learning strategy, reviewed later, is different to style and is concerned more with the way that a student chooses to tackle a particular task. Students are able to make conscious decisions to select strategies that are alien to their preferred learning style.

The late 1960s saw an expansion of interest in student learning styles. Pask (1969) identifies two major types of learner, i.e. the holist and the serialist styles. Holists use global techniques looking at the overall picture to try to establish a broad outline of the problem and then add detail at a later stage. They like to relate specific items to a total model and rely upon relationships between the concepts and the model. Serialists are said to prefer the opposite approach in which they are able to examine the detail, independent of other factors, and gradually build up the overall picture, without necessarily having the total model at the outset of their study.

The two learning styles described above might be considered to be polarised, with an individual learner adopting one of the approaches to the exclusion of the other. Early work by Pask and Scott (1972) and Pask (1976) suggests that learning material should be matched to the preferred learning style to obtain the most efficient learning. However the following alternative view put forward by Entwistle, Hanley and Hounsell (1979) is shared by the author of this thesis. A more complete understanding of academic topics will result if a balance of learning styles is adopted to suit the given learning task. The search for an 'ideal' teaching method is tempered by the view of Entwistle (1981) that the widely different learning styles of students means that there is no single correct way to teach.

An alternative model of learning styles has been proposed, based on the Kolb experiential learning cycle. Kolb (1984) suggests that learning is the process whereby knowledge is created through the transformation of experience. When learning, students pass through a cycle of events in which they undergo a concrete experience, followed by the opportunity to reflect on this experience before appraising the problem during abstract conceptualisation. The cycle is complete when students undertake active experimentation to try out their own ideas as well as the concepts being taught. Based on the premise that students have preferred learning styles, exposure to this learning cycle means that they will feel comfortable when activities match their style and uneasy when there is a mismatch. McCarthy (1981) argues that this process will allow all students to 'shine' at some stage of the cycle and be stretched to develop alternative learning abilities at other stages. This view has been adopted by the author of this thesis and forms part of the basis for a proposed learning model.

A number of other learning style models have been proposed. One of the more recent is proposed by Honey and Mumford (1986a), who argue that to know your preferred learning style is the key to more efficient learning. Activist, reflector, theorist and pragmatist are the four suggested learning styles. These four styles are discussed in the next chapter. They have developed a learning styles questionnaire (LSQ) and used it with over 1000 people, mainly within management training. The questionnaire provides an assessment of the strengths of a respondent in each of the four styles. It is worth noting that, unlike the holist - serialist approach, the four learning styles are not mutually exclusive and a person can have strengths in more than one of the preferred learning styles.

The research reported in this thesis includes a study of the learning styles of groups of second year engineering students at Nottingham Polytechnic. In carrying out the study the Honey and Mumford LSQ has been utilised. The questionnaire is simple to use, easy to understand and can be readily related to the experiential learning cycle adopted in a proposed learning model.

In a study carried out at Lancaster University Entwistle, Thompson and Wilson (1974) related motivation to academic study with personality and study habits. This work was further developed by Entwistle (1975) to include student attitudes in a study of student learning. Deep and surface processing techniques related to individual student characteristics were investigated by Entwistle and Hanley (1978). A learning inventory was developed based on the above (Entwistle, Hanley and Hounsell, 1979) and extended to include the early work by Pask (1976), Ramsden (1979) and Biggs (1976 and 1979). This has become known as the Lancaster inventory. This inventory has been further refined and is reported by Entwistle and Waterston (1988). The inventory consists of 75 items and covers the areas of achieving, meaning, reproducing, non-academic, deep processing, elaborative processing, fact retention and methodical study.

Learning strategies are concerned with the way that a student performs a given learning task. Marton and Saljo (1976a and 1976b) mention both deep-level and surface-level processing and discuss assessment related to processing levels. Deep and surface approaches are also mentioned and discussed by Svensson (1977) and Fransson (1977). Entwistle (1990) suggests that it is essential for students to understand learning strategies and the implications of adopting either deep or surface learning.

The strategy adopted in learning a topic can be linked to the motives for learning. Biggs (1976) first identified the relationship between strategic approach to learning and extrinsic/intrinsic motivation. Furthermore Biggs (1978 and 1979) identifies the three learning processes; reproducing, internalising and organising. It is possible to compare the three processes with surface, deep and achieving learning as adopted in the research reported in this thesis. However Biggs shows a penetration of achieving with both deep and surface learning. For each of these approaches to learning, Biggs defines learning strategies linked to learning motives. Biggs (1987a and 1987b) developed a study process questionnaire (SPQ) consisting of 42 items. The questionnaire allows students to assess their attitudes to learning and to obtain an assessment of their learning strategies and learning motives. Scores are obtained from the SPQ and by comparing scores to published norms, students can assess whether they are surface, deep or achieving learners. The SPQ can be used within a structured study course to highlight alternative learning methods and to encourage deep as opposed to surface learning. The research project has used this SPQ to study the learning approaches of the second year engineering students mentioned above. Learning strategies and motives have been correlated, comparisons made with learning styles and the relationships with student performance assessed.

Technology and learning

An interest in developing computers so that they mimic human reasoning and the thinking processes of the human mind was thought to originate before 1956 when it is claimed that the first artificial intelligence (AI) program was produced (Teresko, 1985). Knowledge based systems, using AI techniques were developed in the mid 1960s. However AI research in the UK declined considerably during the 1970s following the Lighthill Report (Rada, 1990). AI was regarded as a theoretician's tool with little practical application and research in this area was not resurrected until 1983 when a UK government initiative, the Alvey programme, gave a new impetus to AI research. This programme may have been influenced by a Japanese initiative in 1980 to provide a programme of work on fifth generation computers (Fisher, 1986).

'Expert systems' fall within the realm of artificial intelligence. They can be defined as computer programs that exhibit, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert (Ignizio, 1990). Expert systems appear to originate in the early 1980s and typical introductions and alternative definitions have been provided throughout this decade. Advice on the use, application and advantages as well as disadvantages is provided by Miller and Walker (1988), Rychener (1988), Berry and Hart (1990a and 1990b), and Devedzic and Velasevic (1990). The main advantages seem to be that they are consistent in their advice, impartial, explain their reasoning and can replicate the expertise of scarce experts. When considering the application of an expert system the main criteria are that the problem area is well bounded and that the expert knowledge can be captured and defined.

There are two alternative approaches to expert system development. The first involves the use of conventional languages such as C or special purpose AI languages i.e. Lisp and Prolog. The other approach is to use a 'shell'. A shell is a software package that incorporates the logic processes of artificial intelligence and normally includes routines that provide a user interface in which standard input and output forms are utilised. Using a shell the system developer is not required to write the code for the time consuming artificial intelligence and user interface routines. This lets the developer concentrate on the knowledge and associated rules for a particular application. Although shells are not as powerful or flexible as the first approach, using conventional languages, they have advantages in that they are easy to learn and provide a quick convenient environment for the development of expert systems. Johnston (1985) and Vedder (1989) discuss the pros and cons of the two approaches. A concise review with guidelines for expert system applications is provided by Uzel and Button (1987). Within the research project this shell approach has been adopted to develop a module for the assessment of learning styles. This module provides a means of obtaining preferred learning styles and provides general advice on the strengths of the individual styles. The tool selected for the development of this module is the Leonardo expert system shell.

Computer aided learning and computer based training is one area in which artificial intelligence is being applied. Computer based training is thought to originate in the 1950s using straightforward linear programs (Skinner, 1958). Throughout the 1960s this approach resulted in considerable optimism that computers would be able to teach at least as well as the human teacher. However many of the early attempts turned out to be little more than 'electronic page turners' (Rathburn and Weinroth, 1989), and even these limited tutorial systems took many man-hours to develop. It is reported that one hour of courseware can take 100 hours to develop (Yazdani, 1986). The realism in the 1980s has resulted in a general decline in the enthusiasm for computer aided learning (CAL). However it is recognised that there is still a need for quality software for educational needs (Nicolson, Scott and Gardner, 1988) and that CAL can enrich student learning by encouraging different learning processes (Laurillard, 1977). However the rush towards computers as a panacea for all learning has thankfully abated and it is accepted that computers can only be effective when fully integrated into a well designed course (Button and Swannell, 1987).

The use of artificial intelligence in education during the 1980s is claimed to advance both the learning experience and the speed of development of computer aided learning packages. Systems are able to respond with greater flexibility to provide strategies to suit the learner in a similar manner to the successful teacher. These systems, along with multi-media packages are now more able to provide the opportunity for interaction and to allow the student to branch off in different directions to meet the particular learning need.

A different approach for the use of AI within education was discussed by McCann (1981). This alternative concept encompasses computer managed as opposed to computer aided learning. The system is used to assess the experience and knowledge of the student and to provide guidance on learning to the user. This guidance can be provided either as general advice within a 'learning to learn' study course for new students or as guidance on a particular learning task. This latter concept has been adopted within the research project. The role of the proposed expert system is to manage the educational process rather than to provide an alternative means of learning. When fully developed the proposed system will direct students towards appropriate learning material which might be computer based but is more likely to be other learning media.

Overview of thesis

In this thesis there are seven main chapters with the current introductory chapter being the first. Chapter two provides a review of the appropriate literature in the areas of education and artificial intelligence. The educational review is restricted to areas relevant to the research. This covers an overview of learning objectives and engineering education, followed by independent learning and alternative learning methods. Within this section is a comparison of traditional teaching techniques and student centred learning. The review then proceeds to problem solving, including its role and importance, before discussing assessment. The importance of assessment as a teaching aid is discussed, as well as the different methods and uses of assessment. The role of assessment is discussed within the context of mastery learning. The final part concerns assessment of prior learning and its role in increasing access to higher education.

The educational review then moves on to the important areas of learning style and learning strategy. The difference between learning style and strategy is first explained. The background and early work is then presented including holist/theorist styles. The concept of experiential learning is examined, leading to the experiential learning cycle. Learning styles are presented in the context of this cycle and the alternative strategies of teaching to a learning strength is contrasted with the need to develop the weaknesses in a student's learning style. Learning style inventories are presented and compared.

Learning strategies and motives are reviewed and the relationship between the reasons for study, i.e. motives, are discussed relative to the way that learning tasks are approached, i.e. strategies. The three overall learning approaches of reproducing, internalising and organising are considered and compared to surface, deep and achieving learning respectively. The review includes studies into academic motivation related to personality and attitudes to study. Finally learning process inventories are presented and discussed.

The second part of the literature review covers the use of artificial intelligence in education. Initially a general overview of artificial intelligence (AI) is provided including a definition of this technology and a discussion of the advantages and disadvantages. This leads on to the development and use of expert systems. The general structure of these systems is discussed. The use of 'shells' as opposed to a high level language (i.e. C, Lisp or Prolog) development environment is then contrasted. A final commentary is made on the use of computers in education, including computers as teaching aids contrasted with computers as educational management tools.

The development of a proposed learning model is presented and discussed in Chapter three. The model is not presented as the panacea for learning. It is proposed to promote discussion on alternative learning methods and to establish educational concepts that can be developed within higher engineering education. It is considered to be a useful aid to understanding student learning rather than as a definitive model to be adopted in every learning situation. The main object of the model is to promote debate on student centred learning and on self management of the learning process.

The main elements of the model include educational aims and objectives, learning styles and strategies, assessment and experiential learning. The application of this model to an expert system is presented. The intention is that students consult the expert system when commencing their studies to obtain advice on the use of learning styles and strategies appropriate to higher education. The system will then direct students to learning material, not necessarily computer based, which is at the correct level and suits the study needs of the student. After studying the material the intention is that the system will assess students and, where required, direct them to suitable remedial study. The overall development strategy for the proposed expert system is provided. The module on learning styles, produced for the research reported in the thesis, is fully described. This includes details of the knowledge base and the way that the Leonardo shell handles knowledge and the user interface. A second module on project assessment, developed outside of the research, is also briefly reported. The research project, reported in this thesis, concentrates on the learning strategies and learning styles aspects of the learning model.

Chapter four outlines the general methodology used within the research project. Evidence is presented with respect to the reliability and validity of the learning strategy and the learning styles questionnaires. The administration of the two questionnaires with the sample of engineering students is presented, followed by the method of obtaining strategy and style categories from the respective scores. This is then followed by a description of the statistics software that was used to analyse the strategy, style and assessment results. Finally the chapter provides an overview of factor analysis, a statistical technique that can be used to measure the consistency of responses to common items within a questionnaire. This technique has been applied to the learning strategy data.

The data survey and results are presented in chapter five. The rationale behind the selection of the student sample is explained followed by a general description of the sample. Also included is the coding system devised to maintain student confidentiality. The distribution of surface, deep and achieving learning scores are presented for the total student sample. Both strategy and motive scores are presented for all three approaches. The data for the four learning styles is then presented. Activist, theorist, reflector and pragmatist scores are given for the total sample. The final section includes the second year marks for the students. Examinations, continuous assessment, a design project, a computer aided design assignment and aggregate marks form the constituent elements of this assessment. The marks for the total sample are presented in 10 per cent bands which generally correspond to the classification bands for honours degrees at the Polytechnic. A comparison of part-time and full-time student marks is made.

A fuller discussion of the above results is provided in chapter six. The learning strategies and motives for surface, deep and achieving approaches are discussed and compared with data published by Biggs. The differences between part-time and full-time student scores are highlighted and related to the difference in assessment marks for the two groups. Comment is made on the statistical significance of these results. The factor analysis carried out on the learning strategy data is then reported. The procedure utilised in this analysis is discussed followed by commentary on the significance of the results and the relationship with published data from similar studies. The final part of the discussion on learning strategies consists of correlations between learning strategies and motives for the three approaches.

A similar analysis of learning styles is then discussed. Scores for the four learning styles of the engineering students are presented and compared with data published by Honey and Mumford. Again part-time student results are compared to full-time student results and the investigation of correlations between styles is examined. A comparison between continuously assessed marks and examination results is presented and discussed. The differences between these two types of assessment are emphasised as is the differences between the full-time and part-time student marks. Finally the relationships between both learning strategy and learning style with assessment results is discussed.

The final chapter seven summarises the main conclusions drawn from the research and suggests suitable areas for further work.

Chapter 2:
Literature Review

Those who cannot remember the past
are condemned to repeat it.

Santayana

Chapter 2 - Literature Review

2.0 General

As outlined in the introduction to the thesis the background to the research area is the application of a learning model to a knowledge based system in order to promote independent study. Particular emphasis is placed on student learning strategies and learning styles and the relationship with student performance on assessed work. The literature review has therefore been carried out in two main areas being related to:

- education and
- artificial intelligence.

The general literature on education is extensive. Hence it has been necessary to concentrate on specific aspects of education that are relevant to the research. It has been necessary to carry out a relatively widespread literature review to establish a basis for the research reported in this thesis and for future research projects that may result from this work. In establishing this research base it was necessary to investigate a variety of educational ideas and to propose a learning model in order to promote debate on learning methods. This approach helped to establish and understand educational concepts that are relevant to the research. The model, first presented by Button and Swannell (1987) and presented in chapter 3, contains elements on educational aims and objectives, learning styles and strategies, experiential learning and assessment. The areas of learning style and learning strategy were selected from this model as a focus for the research reported in this thesis.

The educational review is intended to cover areas relevant to the learning model. In particular the topics included are learning objectives, independent learning, problem solving, assessment, learning styles and learning strategies. A focus is made on the latter two subjects at the end of the educational review.

Artificial intelligence is a relatively new subject area. However the widespread use of technology has resulted in a proliferation of information on artificial intelligence. The literature search in this area has been generally confined to 'expert systems' and knowledge based systems with a focus of their use in education and tutoring.

2.1 Education

2.1.1 Learning objectives

The statement that *if you don't know where you're going you may end up somewhere else* is particularly pertinent in the world of higher education. The definition of learning aims and objectives is a critical part of education, whether it be in setting out a *mission statement* for the institution or setting out the aims for a lesson plan. It seems appropriate therefore to start the educational review with learning objectives.

Sparkes (1989) highlights the importance of mission statements, which express the educational aims of engineering departments, and then he progresses to set out objectives on the three types of cognitive learning of knowledge, skills and understanding. He also refers to attitudes, values and personal qualities which lie in the affective domain. Educational objectives can be stated at each of these levels and be expanded to higher levels in a taxonomy of learning objectives.

Bloom (1956) sets out a comprehensive taxonomy of learning objectives in the cognitive domain. This taxonomy is probably the best known and the most quoted on learning objectives. The taxonomy, summarised below, defines six levels of learning from knowledge of basic facts at the lowest end to evaluation at the higher end.

> By *Knowledge* Bloom means the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure or setting. Recall involves little more than bringing to mind the appropriate material. Knowledge objectives emphasise most the psychological processes of remembering. At the lowest level knowledge involves the recall of basic isolated facts. At the highest level it involves the recall of theories, structures and generalisations of a subject.
>
> *Comprehension* represents the lowest level of understanding in which the individual can make use of material without necessarily relating it to other material or seeing its full implications. Comprehension can be demonstrated by the accuracy of paraphrasing, the explanation or

summarising of material and at its higher level the extension to other areas (extrapolation).

Application makes use of abstractions in the particular and concrete situations. The abstractions applied can include concepts, rules of procedures, methods, technical principles or theories.

Analysis is the breakdown of material into its constituent parts such that the relative hierarchy of ideas is made clear. The intention is to clarify the material and to show how it is organised.

Synthesis is at the higher end of the taxonomy involving combining elements to form a whole. This process usually results in a pattern that is not clearly there before.

Evaluation is at the highest level of learning and includes making qualitative and quantitative judgements about the value of material and methods for given purposes. The criteria for evaluation may either be given to the student or be developed by the student.

Whilst knowledge and comprehension are necessary learning objectives, the objectives that set higher education apart are at the higher end of Bloom's taxonomy i.e. application and in particular synthesis and evaluation. This taxonomy provides a valuable set of guidelines for curriculum development, course delivery and for planning of assessment.

Carter (1984 and 1985) presents a more recent taxonomy of objectives for professional education. It is proposed that course development be arranged into four components; aims and objectives, course structure, teaching and learning methods and assessment with feedback. He contends that the overall aims of an engineering course should include the preparation of students for effective participation in industry as soon as possible after graduating whilst preparing them for future career development. This view is supported by the Engineering Employers' Federation (1984) when making a policy statement on school education that there is poor correlation between academic performance and engineering performance. It is argued that it is important for employers to be involved in determining the aims of education. Further support for this argument comes from Finniston, Duggan and Bement (1989) who say when discussing higher education that *'involvement of industry is crucial and the restructuring of engineering faculties and departments may be desirable to achieve the overall objectives'*.

Button (1985) in discussing Carter's taxonomy advocates that *'good course design facilitates student learning'*. A means of classifying objectives in terms of what they know (knowledge), what they can do (skill) and what they are (personal qualities) is proposed. Table 2.1 below summarises this taxonomy.

Table 2.1 - Summary of Carter's taxonomy of objectives for professional education

Personal qualities (Being)	Mental characteristics	Attitudes and values	Personality characteristics	Spiritual qualities
Skill (Doing)	Mental skills	Information skills	Action skills	Social skills
Knowledge (Knowing)	Factual knowledge		Experiential knowledge	
	Cognitive			Affective

The taxonomy is useful in both curriculum development and in devising assessment methods. It is suggested that the taxonomy could provide a reference to determine a list of learning objectives and to establish methods of assessment linked to learning experiences. The use of a set of objectives as a starting point for course design seems to be supported by Pudlowski (1987) in that educational goals are essential in the subsequent determination of subject content, and by Chandran (1990) who discusses aims and objectives in the development of a curriculum for engineering design education.

Furthermore defining objectives and providing students with these objectives at the start of a lesson provides a powerful tool in the learning process. Boulanger (1981) recognises six useful instruction techniques including pre-instructional strategy. By supplying learning objectives prior to a lesson, the students' attention can be focused on the subject area, and interest can be generated such that student motivation towards the subject material is increased and conceptual learning improved.

Engineering education. Prior to the 1980s engineering education tended to define learning objectives in terms of the engineering sciences, concentrating on the cognitive domain. However since the Finniston report (1980) there has been a change in engineering education towards a greater emphasis on applications, the business of engineering and the engineering dimension. This implies the perception of a need, the knowledge and skills to satisfy that need and the capability either to create a product and the ability to sell it at a profit, or to provide a service at a competitive economic cost (Button and White, 1987).

The Engineering Council (1984) defines engineering and states:

> 'The work of a Chartered Engineer is therefore predominantly intellectual and varied. It requires the exercise of original thought and judgement concerning the development of new systems and technologies, the ability to supervise the work of others and, in due time, the maturity to assume responsibility for the direction of important tasks, including the profitable management of industrial and commercial enterprises. In their work Chartered Engineers have a responsibility to society with regard to the ethical, economic and environmental impact of technical need and changes.'

The above provides support for the argument that engineering education needs to be more broadly based and include many objectives that extend the activities of students beyond technical considerations. Many of these additional activities are included in what has become known as the 'hidden curriculum' (Bergenhenegouwen, 1987). There is however a need to make explicit many of the features contained within this hidden curriculum, such as developing student initiative, innovation, creativity, problem solving ability and communication skills. The following objectives are taken from a new BEng Honours Integrated

Engineering (1990) degree course. They illustrate the explicit use of objectives that are both technical and those that at one time might have been included in the hidden curriculum.

To educate a student to have a grasp of the fundamentals of the disciplines of manufacturing, mechanical, electrical and electronic engineering.

The programme is designed to provide:

an understanding of the relationships and interaction between the above engineering disciplines

an awareness of the use and application of computing and microprocessors in engineering.

It was designed to develop:

an understanding of the integrating role of an engineer

the personal qualities that are required of a Chartered Engineer including independence and initiative, problem solving and communication skills and the ability to self learn

a systematic approach to problem solving across a span of engineering disciplines

initiative, enterprise and creativity

the ability to reason logically, to solve problems and to communicate clearly, both verbally and in writing

the ability to read critically and to research material relevant to a particular problem or project

an awareness of the commercial and business aims of an industrial company

an appreciation of industrial relations, industrial law and safety an understanding of the role of a professional engineer in society.

The above list is not exhaustive. The objectives were selected to show a range used in a modern engineering degree course, and in particular the emphasis of the affective domain in developing curricula. In developing these objectives the criteria contained within Carter's taxonomy (see above) were used as a reference point. Smalley (1989) supports the need to include non-technical objectives in asking whether engineering education needs a radical shake-up in order to encourage creativity and inventiveness within students.

Summarising, learning objectives are an important starting point in the development of courses and the associated curriculum, and as part of the teaching and learning process. Preparation of learning material should start with objectives and material be produced relative to these objectives in much the same way that an engineer designs a new product relative to a detailed design brief. In particular objectives covering the affective domain need to be explicitly stated. It is no longer sufficient to rely upon the hidden curriculum.

2.1.2 Independent learning

Few people remain in the job for which they were initially educated and trained. In particular engineering graduates often move into managerial posts that require a completely different set of skills to those learnt on their initial courses of study. When following a degree course it is important that problem solving and communication skills are developed along with the ability to learn independently. An accumulation of facts and knowledge is not sufficient. It is therefore necessary to obtain a broad competence for lifelong autonomous learning in order to have the capability to adapt to future career changes. *'Questioning insight must be developed within the student no less than that programmed instruction shall be absorbed'*, Revans (1989). In other words students must develop the techniques and ability to think and educators must not rely solely upon knowledge transfer. To develop these skills students need to be encouraged to develop learning techniques based on independent learning in an active way such that they take responsibility for their own learning. Van Rossum, Deijkers and Hamer (1985) report that students perceive active learning as being synonymous with deep-level learning.

Traditional education within a Polytechnic and other engineering degree courses is based on formal lectures supported by tutorials, seminars, laboratory work, projects and industrial experience. Gibbs (1989) reports the HMI commentary on older more traditional methods within *The English Polytechnics* as:

- relying on an over dependence on one way of teaching and learning, often the formal lecture, so that students do not develop a range of skills appropriate to higher education;

- spoon feeding in lectures, seminars and practical work, so that students become over dependent on the information selected and provided for them by their teachers;

- incorporating assessment methods which place too high a premium on the ability to recall factual information.

However alternative learning methods using a variety of learning resources now pervade many of these higher education environments.

Traditional education is categorised by teacher centred learning. Holdzkom and Blutz (1984) discuss teaching strategies and ask what teachers can do to improve teaching. They say that traditionally the lecturer is in control of the learning situation and leads the class in discussion. There is little effort to explore unfamiliar situations and lecturers are wary of studying areas in which they have little expertise. The curriculum is often text book led and follows set texts with strong reliance on teacher guides. This approach has its place within a course, however over reliance on one method of teaching and learning is likely to lead to a suppression of inquiring minds and will encourage rote learning limited to satisfying specific goals and objectives. Culver (1987) presents a case for providing unstructured alongside of structured learning experiences in order to give students more control of their learning. Students perceive that they have a limited input to the learning experience and are discouraged, or at best not encouraged, to state their opinions, discuss subjects and generally to be creative. Lecturers can become imprisoned by the curriculum and assessment methods, and feel that they have little option but to pass on information relevant to the examination.

Student centred learning is the alternative to *teacher* centred learning. Students are encouraged to take responsibility for their own learning and the *'curriculum is more than texts and includes the total classroom environment'* (Yager and Penick, 1984). Students play a more active role in setting and developing learning objectives, work is more self guided involving student planned activities. The author of this thesis recommends Gibbs (1981) who provides a comprehensive overview on educating students to learn and on student centred learning. Engineering degree courses already contain a significant element of student centred learning in the form of assignments and projects, and in discussing projects, Varahamurti and Curtis (1987) contend that *'the student becomes very deeply involved in the learning process'*. One major source is design projects carried out both individually and in groups which, along with the major study project, can form up to 40 per cent of final year studies.

The advantages of projects in developing student attitudes and personal skills is presented by Creese (1987) in discussing project centred engineering courses at Aalborg University in Denmark. The major advantage, re-iterated by Vajpayee and Arguelles (1990), is the ability to work as part of a team. Prins (1991), in looking at the relationship between time and quality within projects, expresses the need for students to experience the design process to develop project skills using relatively easy problems. Evans and Bowers (1988) argue that design in engineering education has systematically been replaced by engineering science and analysis and that there is a need to return to conceptual design through *doing engineering rather than listening about it*. As Hawlader and Poo (1989) suggest when cultivating talents of students *'the most deliberate way to develop creativity is by practising creativity'*. Dixon (1991) reports the complimentary comments of industry with regard to the teaching of the engineering sciences, however his view is that engineering design education is not as successful and that industry continues to be dissatisfied with this engineering design education. Whilst it is essential that engineering students experience design through project work; it is not sufficient to rely upon experiential learning methods alone. Students must also be taught the design process and methodology in an explicit manner. The Moulton report (1976) suggested that engineering courses be taught in a design context *'so that design is a continuous thread running through the teaching of undergraduate engineering'*.

It is the view of the author of this thesis that design projects, when adequately resourced and supported, provide an excellent means of educating engineers. Students are able to apply many of the technical and managerial concepts taught within a course. They also provide an ideal vehicle to promote and develop independent learning, providing many opportunities for student centred learning. Projects have been a major source of student centred learning for many years within engineering education. Whilst it is not advocated that courses become over reliant on project based learning, this mechanism provides a powerful technique for developing the personal and technical skills of engineering students.

Other student centred strategies include the use of learning activity packs, case studies, assignments and mini-projects. The use of assignment based learning, in which the student is given the study brief at an early stage, encourages students to take the lead in the classroom and can even result in students requesting information and specialist lectures on topics. The role of the lecturer moves from teacher to facilitator acting as a catalyst to learning as a learning manager. The lecturer is able to adopt a variety of roles including enabler, helper, facilitator, director and time manager.

Suitable learning material is required for independent study in which students can study at their own pace, at their own time and at their own chosen location. Weaker students have the opportunity to gain mastery of the subject material by studying for longer periods, whereas more able students can either proceed at a faster rate, spend less time in formal study or go further within a topic. As such students do not become frustrated either by becoming lost or by being held back. Students can set their own timetable to keep pace with the learning objectives and better students can be encouraged to extend themselves beyond the confines of the defined objectives. When linked to self assessment students are able to determine the remedial studies that are required to obtain mastery of the material to be learnt.

Introducing alternate learning methods into an organised course, in which students are encouraged to become independent in their learning, can develop skills. These methods may facilitate the development of skills within the affective domain including:

- initiative and independence
- self awareness and adaptability
- self confidence and self reliance
- organisation and self management
- ability to research and become autonomous learners.

The above objectives are extended by the need to develop deep learning, in which the student is encouraged to become immersed in the subject to obtain a good understanding of the material, as opposed to rote learning methods based on the reproduction of facts. Other advantages that result from adopting these methods can include the production of learning material to supplement scarce teacher resources. It also often results in the production of learning material of a consistent quality that is directly related to student needs for a given topic. This provides a useful source of revision and support for formal lecture programmes. Button and Dobbins (1985) report favourable comments from students who have followed an independent study course using tape/slides for engineering thermodynamics. Provision for different learning styles and methods can be made by having a number of different learning packs to suit individuals.

Educationalists have in the recent past extolled the virtues of alternative learning methods and have offered wide ranging ideas for introducing and developing these techniques. In particular the range of texts based on *53 Interesting ways to ... (Gibbs, Habeshaw and Habeshaw, 1987a, 1987b and 1988, and Habeshaw, Habeshaw and Gibbs, 1987)* present and discuss a comprehensive treatment of alternative methods to be used in learning and in assessing teaching methods. A discussion on improving lectures to promote active student participation in this traditionally passive area of teaching is presented by Brown (1987 and 1989), Gibbs (1982), and Gibbs, Habeshaw and Habeshaw (1987c). An interesting technique deserving special mention is *Teaching innovation weeks* (Jaques and Gibbs, 1988). The principle of this technique is that one week, approximately midway through the year, is dedicated to alternative teaching methods. All participating lecturers on a course, within a department or over the whole institution, use a novel alternative teaching technique and report back on the experience. This provides a means of experiencing new methods and encourages innovation within teaching teams. This innovation is supported by *147 ideas for non-traditional teaching* (Gibbs, 1987).

The major disadvantage is that good independent learning material and study guides are limited in number, not readily available and are both difficult and time consuming to produce. The material is also not necessarily transferable to other courses or different groups of students. The expense of staff time in producing learning packs can be prohibitive, particularly with computer aided learning (CAL) packages. There is a need for lecturers to accept that the material they produce should be available to the course team and not for the sole use of the developer. A reluctance by many lecturers to adopt 'new gimmicky' methods of teaching may inhibit the introduction of these methods, however as discussed by Willis (1990) the reason for this reluctance might be the failure of educationalists in disseminating information in a way that is useful to lecturers. Many educational innovations are sensible but it is often unclear as to how these ideas are implemented within a course or teaching-learning session. A strong argument for a need to educate engineering educators is further presented by Cowan (1990). This reluctance may also be increased as institutions progressively push lecturers towards more independent study methods for their students. These tactics involve the imposition of higher ratios of students to academic staff and the call for less formal class contact. However the introduction of these methods into a course can have major implications for tutor support at times that are less convenient and less economic than more formal activities.

'Alternative' methods can result in a feeling of isolation in which the student feels uneasy in a new and different learning environment. Fay (1988) identifies interdependence, rather than independence, as being the critical factor in student centred learning. It must be recognised that there is a major difference between student *centred* learning and student *abandoned* learning. Good study packs that provide a high level of support for independent learners, such as Open University material, are expensive and time consuming to produce. Taylor and Kaye (1983) comment on the anxiety of Open University independent learners when choosing and carrying out projects, and highlight the challenge in designing good mass-produced packaged courses. When students find a study pack difficult they might be tempted to work through it without understanding. The higher education 'culture shock' is a well known phenomenon in which a significant number of otherwise capable students are failing because they are unable to adapt to the need to take greater responsibility for their learning. Fry as early as 1972 reported that whilst high aptitude/inquiry student types responded well to student centred techniques, the attitude and performance of low aptitude/inquiry types is reduced. In the short term familiar teaching techniques are likely to result in the best results. Students therefore need time to adjust to the greater responsibility of independent learning before the benefits are accrued, and there is an argument for induction programmes at the start of courses of a substantial nature.

In this situation there is an increased need for 'pastoral' care of students and, whilst lecturers must recognise this need, institutions also have a responsibility to provide lecturers with the time for this activity. In effect the saving in a lecturer's formal teaching time may be lost to this pastoral care; the initial production of learning material will certainly swamp this saving. Dedication and teamwork is required from lecturers to introduce new methods. Geis and Coscarelli (1987), in asking *'Why do we teach when we shouldn't?'*, contend that it is people and not systems that should be the focus of change. Teamwork within staff is particulary important when delivering learning across multi-disciplinary projects in which it is often necessary to have two or more tutors with different subject specialisms. A discussion on team teaching including its advantages and disadvantages, and advice on its introduction into a course is provided by Fox (1990) and by Durcan and Kirkbride (1990). The institution also has its part to play by providing the time and space for the necessary planning activities and by providing support through staff development. In order to maximise the benefits to students of team teaching, the size of student groups must be sufficient to support two or more tutors within a given timetabled slot.

For alternative learning methods to be effective they must involve students in active participation to improve their learning skills rather than passive listening to precepts. Students need time and space for reflection in order to understand the process of learning as well as the content. Whilst Vermunt and Rijswijk (1988) express the view that *'Independent learning in its most extreme form means that students are their own teachers'*, it should always be remembered that the lecturer is still the most important variable in the classroom. The Council for Educational Technology (1984) in discussing independent study emphasise that the teacher's role is even more important with self-study methods. This is re-enforced by

Hodgson (1985) in highlighting the importance of study support systems alongside of learning material for the independent distance learner.

2.1.3 Problem solving

Problem solving within education forms a powerful teaching strategy. Bloom (1956) identifies problem solving as a high level skill. It establishes a realistic framework for the application of theoretical principles and provides motivation for students to learn. This is re-enforced by Byrne and Johnstone (1988) who state that *'The need for relevance in science education has always received wide acceptance even if its realization has proved elusive'* and by Rosati (1987) who asserts that *'problem-solving is the most important skill of the professional engineer'*. The author of this thesis would contend that there are many other equally important technical and personal skills, however it is accepted that problem solving is invaluable in delivering learning objectives that cover both the cognitive domain as well as developing many of these personal skills and qualities. Whilst problem solving is a valuable teaching strategy, it should not be considered as the only means of learning. In discussing problem-based teaching and learning, the Organisation for Economic Co-operation and Development (1989) state that *'the aim of education is not just to produce good lawyers or scientists or historians, but to produce good thinkers'*. Problem solving is highly student centred and forms an important function in engineering degree courses. The following diagram, taken from *Problem Solving in School Science* video packs (East Anglian Resource Organisation, 1985), illustrates many of the benefits to be gained from problem solving.

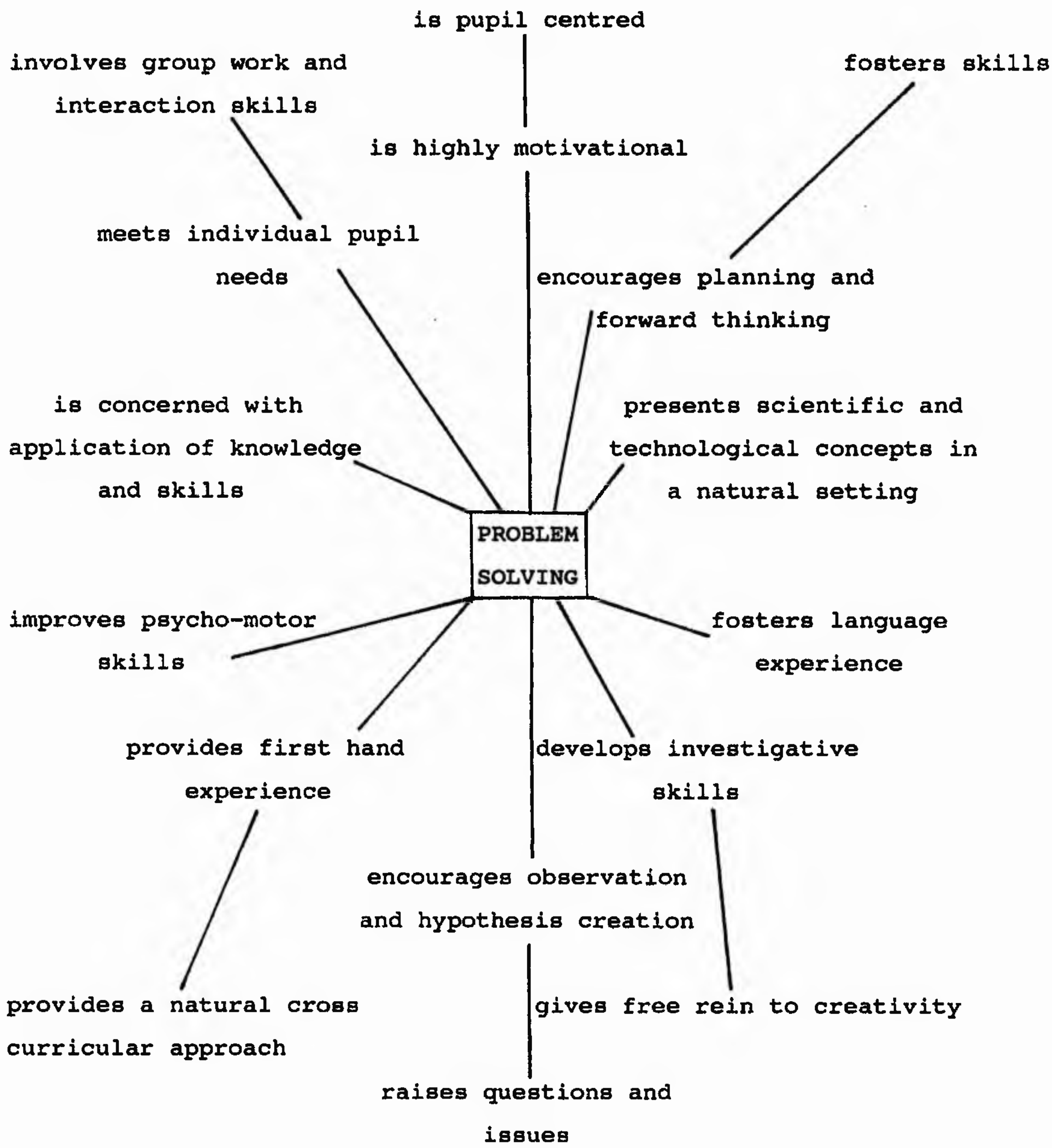


Figure 2.1 - Problem solving

Types of problems range from closed problems, in which there is normally a 'solution' that the student is encouraged to find, to open ended problems where there is no unique solution. Both types are beneficial and of equal value within engineering education. Holt, Radcliffe and Schoorl (1985) discuss the applications and limitations of traditional academic problem solving and argue for open ended problem solving using engineering design, combining the analytical approach with systems thinking of a more generalised nature including other non technical factors. Collins (1985) contends that engineering undergraduates need practical as well as the normal design skills of analysis and synthesis, and that in order to gain problem solving skills they must repeatedly be exposed to problem solving in a practical situation. The concepts and benefits of problem solving are also embodied within the national curriculum for school science and technology.

Closed analytical problems are a well used strategy in the teaching of engineering science subjects. Students are presented with tutorial questions based on engineering applications and are expected to apply sound analytical and practical principles. Frazer and Sleet (1984) discuss the difficulties that many students have with closed problems. This is supported by Mettes (1985) who, in discussing learning to solve science problems, asserts that *'beginners lack large and well organized systems of procedural knowledge'*. In order to overcome these difficulties in solving closed problems students need to apply an appropriate strategy. A comprehensive and detailed process for problem solving is given by Pilot, Mettes, Roossink and Donders (1981). A general strategy based on Polya (1957) is suggested below.

INPUT => PROCESS => OUTPUT.

The INPUT stage involves summarising the problem in order to get to know and understand the problem. Numerical data given in the problem is stated along with symbols and units, suitable diagrams are drawn and statements paraphrased for clarification. It is then useful to establish and state the unknown data that can be found to contribute towards the problem solution. It is important that the problem is fully defined and understood before a solution is sought. Students must ensure that they establish the problem to be solved and not solve what they would prefer the problem to be.

In carrying out the PROCESS stage it is useful to devise and adopt an appropriate plan. Many analytical problems are based on previous problems and students should try to relate to these. They should work forward from the data given towards the solution or a partial solution. If this is not fully successful they should then proceed to work backwards from the unknown data and try to build bridges by finding links between the input data and the unknown data. In carrying out the plan for solving analytical problems it is necessary to adopt a logical and structured approach that involves the substitution of data into formulae, the segregation of numerics and units, the use of unity brackets where appropriate and the rounding of numerics at the end to avoid rounding errors.

The OUTPUT stage involves summarising and stating the final solution. It is also important to check the solution to ensure that it is within a range of expected answers and that it results in the correct units. An answer of 20 N for a pressure has the wrong units and would suggest the use of an incorrect formula or substitution. It is necessary to ask questions. Is the numeric of the right order? Are the units consistent, and does the answer seem about right or is it wildly wrong? The steps in the argument need to be checked to confirm that they are consistent and logical. Finally the question should be reviewed to ensure that all parts of the problem are solved and that all of the information provided in the question has been used.

Lecturers have a proactive role in developing a student's strategy in solving closed problems. One approach is to use a pre-instructional strategy and start by presenting students with the final and most advanced problems that they are expected to be able to solve, thus alerting students to the expectations of the particular learning objective. This should be accompanied by setting the scene and emphasising the need for a rigorous and structured approach to problem solving. Students can then be 'taught' how to tackle straightforward problems, practice on problems that become progressively more difficult culminating in advanced problems. In presenting the problems at an early stage students are able to recognise the material that is necessary to solve the problem and become motivated to prompt and request lecturers for information. In adopting this approach the proper emphasis is made on structured techniques of problem solving and students are encouraged to take responsibility for their own learning.

Open ended problems have no unique solution and require students to adopt a structured approach in order to achieve an effective and efficient solution. Projects and assignments form an ideal basis for developing problem solving abilities. The responsibility for learning is moved towards the student and effective projects become the student's possession in such a way that student motivation becomes increased. As well as 'learning' new material students learn techniques of problem solving and develop personal skills of initiative, independence, teamwork, perseverance, enterprise and effective communication. British Gas (1985) highlight that the success of problem solving lies more in terms of the process rather than the practical outcome. These skills are of lifelong value, certainly well beyond the time when students have forgotten most of the things that they have learnt.

A methodology for carrying out engineering design projects has been adapted from Sharing Experience in Engineering Design (SEED, 1985), Open University Unit T392 (1984) and Cross (1989). This methodology is summarised below:

identification of need
|
identification of problem
|
product design specification (PDS)
|
alternative design concepts
|
selection of optimum design
|
detailed design
|
review the solution
|
communication.

Whilst the above is specific to engineering design projects it can be adapted for use in most types of open ended problems within engineering education and other subject areas.

The role of the teacher in project based learning is important if students are not to become frustrated with the problem and a good structured approach is to be developed by students. At the start of the project students must be provided with a clear comprehensive brief. Adequate resources in terms of materials and equipment must be provided, as well as good source material for researching the problem. The role of the teacher through the project moves from initiator and motivator to traditional teacher to consultant and finally to assessor. The open nature of projects results in goals which can seem vague. Initially students find this disconcerting. Indecisive hesitant students need greater attention and guidance in order to develop their confidence in project work. Some students are better at projects than others, and interestingly problem solving ability is only weakly correlated with general ability as determined by IQ measures (Kempa and Nicholls, 1983). Tunnicliffe (1986) observes that many of the 'less academic' are good at many of the skills needed for effective problem solving.

The major task for the teacher is to act as a facilitator throughout the project, guiding students toward recognising what is possible and not allowing students to spend too much time exploring 'blind alleys', rather than as a provider of knowledge. *'... discovery under guidance is more effective and leads to greater retention and transference of what has been learned than autonomous discovery'* (Perez and Torregrosa, 1983.) This role is unnatural for most teachers who are used to controlling the learning situation and leading students along well trodden paths avoiding unfamiliar areas. The situation can be threatening, particularly when students start to explore unfamiliar ground and both teacher and student need to come to terms with the fact that the teacher does not know everything and it is acceptable for the student to take responsibility for researching a topic. However, a good well managed project that results in a satisfactory solution is an enriching learning experience for both teacher and student.

2.1.4 Assessment

Methods of assessment should be considered at the outset of course and curriculum development. Assessment can have a major effect on the teaching and learning process. Continuous assessments and examinations must be used so that they promote and test the deep learning skills that are said to be valued in higher education and to increase student motivation and learning. As such it should be used positively and not merely as a means of grading students; assessment is not necessarily the same as grading (Rowntree, 1986). Ebel (1979) provides support for this view by expounding the opinion that, as well as grading students, assessment should also be used for the improvement of teaching, for self testing by students to determine what has been learnt and to a certain extent for public accountability. Finally, Lawton and Kingdon (1989) demonstrate the importance of assessment; '... *working with teachers in the development of valid, efficient and exciting assessments'*.

Why do we assess students? The two main purposes of assessment are to grade students (summative assessment) and to provide feedback to students (formative assessment). Summative methods often occur at the end of an academic year or at set stages within a year, i.e. end of term or semester. Students are assessed to allow academic staff to judge students in order to decide:

- whether they should enter a given study programme
- whether they should proceed to the next stage
- on the grade to be allocated at the end of a course
- whether they know the subject matter and understand the concepts.

When grading students it is necessary to decide between a system which is based on a set of fixed pre-defined criteria, (criterion referencing), and a system that compares a set of students relative to each other (norm referencing). In higher education both strategies seem to be adopted at the same time. Lecturers set assessments against specific pre-set objectives, holding a personal value of the standards that they feel need to be maintained. At the same time, at examination boards, the performance of a set of students are considered relative to each other and pass marks, if not the spread of marks, are often adjusted. Reference is also made to previous decisions and judgements on student performance.

Formative assessment is carried out throughout the study period, and to be most effective it should be provided as soon as possible after the student has submitted the work. Feedback allows students to assess their strengths and weaknesses and allows them to determine how they are coping with the course. Students can ascertain the expectations of lecturers and appraise their own deficiencies along with the improvements required to meet expectations. Formative assessment is of greater value to students than summative and if used sensitively it can be invaluable as part of the learning process in highlighting those areas in which remedial work is required and in providing confidence to students. This type of assessment can be provided either by the lecturer, through peer assessment or by self assessment. *'Self assessment is an important ability not just in* *design but in all aspects of learning and professional life'* and *'it is an important aspect of learning how to learn'* (Boud, Churches and Smith, 1986).

Formative assessment is widely used in course work. However there is a move within education to combine summative with formative assessment in the form of an increasing use of continuous assessment. Students carry out assignments and projects and are given feedback throughout the work and at the end of the particular piece of work; not necessarily at the end of the year. This provides teachers and students with an assessment of progress throughout the course as well as a mark that can be used for grading purposes at the end of the study period.

In order for assessment to be effective it should be used in such a way as to allow students to demonstrate what they know rather than what they do not know. In providing assessment it is necessary to examine all of the objectives within a course including educational, vocational and intellectual. A balance should be found between the theoretical and practical aspects of the course. Assessment of students' performance against course objectives needs to be carefully considered.

A balance of methods will contribute towards assessment across the objectives as defined by Bloom's taxonomy and across Carter's range of professional objectives. *'... properly designed assessments create and enhance the conditions for effective learning'* (Heywood, 1989). Whilst it is important to test a student's knowledge and understanding of subject matter, within higher education it is more important to encourage the higher order abilities of synthesis and evaluation. Assessment has a critical role to play in developing the right approach to deep study in which the simple regurgitation of factual knowledge is only of limited value. Over reliance on the use of testing the lower order objectives is likely to encourage students to believe that surface techniques are the key to success.

There are a variety of assessment methods currently available, ranging from short sharp objective tests, which tend to assess the lower end of the learning objectives, through to open ended projects, which test the range of cognitive and affective domains as well as higher intellectual skills. A fuller description of methods is provided by the Business and Technician Education Council (1986) in giving general guidance on assessment and grading. The Council for National Academic Awards (1989a) also provide advice on assessment mainly based on cognitive skills. The following list, whilst not being exhaustive, indicates the range of assessment methods.

Objective tests of facts and knowledge can take the form of short tests in which the student answers a large number of short questions. They are used as a diagnostic tool by teachers and can provide formative assessment for students. In certain courses, particularly Business and Technician Education Council (BTEC), they are used as summative tests and the results are often combined with an end test. The use of multi-choice tests has led to a wariness of short tests for grading. However well constructed multi-choice questions can provide a valid means of testing students. One of the criticisms of this type of test is that students with partial knowledge can often 'guess' the correct response. Nonetheless Hutchinson (1982) argues that all knowledge, full or partial, should contribute to the final assessment and credit should be given for 'intelligent guessing'.

Essays form open ended assessments which generally test analytical and evaluation skills.

Predisclosed questions which allow students to prepare for assessment have less reliance on memory and greater emphasis on higher skills.

Open book examinations involve even less reliance on memory. There is a need to be careful in the formulation of questions such that students gain credit for applying material rather than copying existing notes or following identical problems covered in earlier tutorial sessions.

Unseen examinations are the norm in higher education. A well balanced paper will test all of the skills within Bloom's taxonomy with students being able to obtain a bare pass mark with an understanding of the subject and a grasp of the facts, and obtain higher grades by demonstrating skills of application, synthesis and evaluation. The normal format of examination involves a choice of typically five questions from eight. Gibbs, Habeshaw and Habeshaw (1986) in suggesting *53 Interesting Ways to Assess your Students*, argue that this can lead to '*selective negligence*' in that students deliberately focus on limited sections of the course during examination preparation.

Projects afford an opportunity for student development across a wide spectrum of activities, as well as providing a means of both summative and formative assessment. In discussing undergraduate engineering projects and assessment Allison and Benson (1983) recognise that they are an essential feature of engineering degree courses but acknowledge the difficulty of assessment and uniformity in marking. Assessment of projects takes many forms including oral examination in informal sessions, formal assessment meetings, written reports, verbal presentations and viva voce where students orally defend their project to an examining team. Projects often involve group work which leads to problems in identifying individual contributions. Techniques are available in assisting with this task including peer assessment. Jeffery and Swannell (1991) report on the experiences and difficulties of assessing a large group project in engineering design, and the need to exercise caution when using group peer assessment.

Further advice and discussion on assessment is given by Gibbs and Habeshaw (1990), and a variety of case studies highlighting less conventional techniques for assessing students is given by Gibbs (1985a and 1985b).

Coursework can form an important function within the learning process. It provides a non threatening means of assessment allowing students to obtain feedback on their performance. The use of informal assessment with consequent low levels of threat and anxiety are of benefit in that it allows students to gain confidence for future tests. Rocklin and Thompson (1985) found that students perform best on hard tests when their anxiety levels are low, moderately anxious students perform best on easy tests and the most anxious students performed worst of all. Within engineering the most common form of coursework involves laboratory work which has the aim of assimilating theoretical work in a practical situation. Unfortunately, with the increase of continuous assessment, coursework is becoming less important and is perceived by lecturers and students to be more of a chore than a valuable learning experience. The role of coursework is being diminished by the pressures of student workload in engineering degrees and it is now opportune to assess the need for formal coursework that does not directly contribute towards the final grading of students. The need for formative assessment is not disputed, however this can be provided within the normal seminar and tutorial situation. The pretence of using coursework as a means of formative assessment should be discarded.

All types of assessment are valuable within a course. In order to succeed, both in education and in a future career, it is necessary to remember facts and techniques, to be able to research new areas using self learning skills as well as to use personal skills such as initiative, independence, perseverance, innovation and creativity. Assessment of students, relative to course criteria, can have a major effect on teaching and significantly affect the learning process. Assessment methods should allow all students to demonstrate their strengths in different areas, not just those that are good at passing examinations. The different learning styles and academic attributes of students should be satisfied as much by assessment methods as by teaching methods. Canelos and Catchen (1989), in their study of testing intellectual skills in engineering, concede that student motivation most related to classroom testing is based on the desire to achieve good grades. However, students who sense that success in examinations by the recall of facts, rather than in the use of higher order skills, will migrate towards surface learning rather than the deep learning techniques so esteemed in higher education.

The Kellar plan (1968) sets out a system of learning which is based on a system of assessment and has the objective of developing independence in learning by giving the responsibility to students. The plan involves dividing the course into a number of small self-study units supported by tutorial help when required. When the student has completed the unit of study a test is carried out. If the material has been mastered the student progresses, otherwise remedial study is necessary with subsequent re-testing. Mastery implies a mark nearer to 90 per cent than 40 per cent. Good students will complete all units of a course in less than the allocated time, whereas poorer students will not complete all units, but will have mastery of those completed. In this system, passing the course might be measured as complete mastery of 40 per cent of the units rather than being only 40 per cent efficient in the whole of the syllabus. Dunkleberger and Heikkinen (1983) discuss mastery learning and conclude that whilst a greater teacher commitment is necessary, the self-pacing element has advantages in developing the independence of learning in which the role of the teacher changes from a dispenser of information to a facilitator in the learning process. Mastery learning, with its associated assessment methods, can alter what is learnt, how it is learnt and the student's enthusiasm for learning.

Experiential learning. In the current educational climate of increasing student numbers, plans to expand higher education provision (*Higher Education: meeting the challenge*, 1987), and the re-evaluation of access criteria for mature students, it would be remiss to omit Assessment of Prior Experiential Learning (APEL) within a discussion on assessment. The CNAA development Services Brief No. 4 (1988) provides an overview of APEL. In particular it is defined as:

> *'... the knowledge and skills acquired through life and work experience and study which are not formally attested through any educational or professional certification. It can include instruction-based learning, provided by any institution which has not been examined in any of the public examination systems.'*

Two studies, Further Education Unit (1983) and CNAA Development Services Publication (1984) showed, at that time, that there was no evidence of the systematic use of APEL for admissions purposes despite the fact that there was nothing in the regulations of any award bearing course in higher education to prevent it.

The rationale of APEL is that there are potentially significant numbers of mature students who do not have formal qualifications in terms of GCE 'A' levels, BTEC or others, but without doubt have the ability to succeed on a degree course by the strength of the knowledge and skills gained in experience of life and work. In assessing mature candidates for entry into higher education it is fundamental that the right balance is found between providing the opportunity for achieving higher qualifications and protecting the student against the likelihood of failure. Whilst the philosophy of increasing access is to be encouraged, it is necessary to consider the risks involved in sacrificing an existing career and family life.

If nothing else APEL must therefore be capable of providing a good indication of the likelihood of success and be capable of matching the student to the appropriate level and type of course. In discussing Accreditation of Prior Learning (APL), The Business and Technician Education Council (1990) suggest that the process focuses on assessment and certification, and through APL alone successful candidates can obtain eligibility for individual units and even full First, National or Higher National qualifications.

Experience relevant to learning is the main criteria to be used in assessing the mature student, and the process of identifying this learning is a demanding task for which the candidate must take equal responsibility with the assessing institution. The process of identifying experiential learning and presenting the case in an organised manner is in itself a valuable exercise that helps to prepare candidates for a return to education. It is suggested that this process could constitute a formal course in higher education. The assessment, which should be based on academic criteria, is the responsibility of academic staff. The assessment of suitability and the award of appropriate credit for advanced standing based on experience is an onerous task. Faced with this task admission tutors tend to err on the side of caution relying upon formal qualifications. It is the obligation of the candidate to convince staff that they should be given credit for appropriate experience. However, staff need to provide guidance and assistance in this process.

2.1.5 Learning styles

There appears to be a recent growth in interest amongst educational researchers in both learning styles and strategies. Whilst these two terms are closely inter-related and appear at first sight to be inseparable, there is a clear distinction that needs to be clarified and understood. Learning styles are concerned with a student's preferred way of learning and are part of the characteristic and profile that a student brings to a course. Whereas learning strategy is external to the student and is concerned with the way that he/she chooses to tackle a particular learning task. To emphasise the difference it is worth noting that in certain learning experiences the student may benefit from adopting a strategy that is alien to the preferred style. Entwistle (1979) reports Pask as distinguishing learning style, which is a relatively stable preference of a person for a characteristic way of learning, from learning strategy which is a response to the requirements of a particular task.

Preferred learning styles are thought to relate to the personality and characteristics that a student possesses. A preferred learning style is part of the profile that a student brings to a course. Although it may be further developed and altered throughout the course of study, it is intrinsic within the study preferences of the individual. Learning styles are developed over a number of years in such a way that a student will benefit more from a learning experience that suits the individual style than from one that is opposed to the preferred style. Entwistle (1981) stated that *'the existence of widely different learning styles prevents there being any single correct way to teach or to learn'*. Riding and Ashmore (1980) reinforce this view in asserting that those children who are taught consistently by means that are not suited to their learning style will perform less well than they could and may give the impression of being less intelligent than they really are. Their work, which categorised the learning styles of children into verbaliser (those who learn and think in verbal terms) and imager (those who prefer to learn and think in terms of images), suggests that learning style is independent of intelligence. Riding, Buckle, Thompson and Hagger (1990) applied the verbal-imagery model to a computer package that could be used with an individualised computer based training (CBT) package. The need to match the mode of presentation to suit the trainee's learning style and the potential for use in CBT is identified.

Holist - serialist styles. Several different learning style techniques have been identified and evolved. The holist - serialist is one such approach. The distinction between these two major categories of learner was first made by Pask (1969) and Pask and Scott (1971). A holist approach uses global techniques initially concentrating on the broader outlines of the problem then fitting in detail at a later stage. The holist looks at several broad aspects of the problem at the same time in order to gain an overall global picture and a variety of inter-relationships. Serialists, however, use the opposite approach and concentrate on the analysis of individual items of data using a step-by-step approach in order to build up to the complete picture. Their preferred method is to fully analyse data from basic fundamentals in order to seek and develop links and structures towards the overall goal. Holists work from the 'top down', whereas serialists work from the 'bottom up'.

Early work by Pask and Scott (1972) investigated the differences in styles when subjects carry out a free-learning task. The free learning task involved a zoological taxonomy. Students were required to question five categories of statements inscribed on cards placed in separate piles according to their category. The student is given a limited period in which to work, is allowed to ask any question providing a reason for asking is given. The questions asked and their reasons are recorded. Their responses and the strategies used indicate the preferred learning strategy of the students. Holists ask questions about broad relations and form hypotheses about generalisations. Serialists ask about much narrower relations and their hypotheses are specific.

Pask (1976) reviews previous results of investigations into differences in learning styles and proposes a theoretical basis for the classification of learning styles. Under extreme experimental conditions large learning differences were demonstrated. It is argued that holists perform poorly using serialist material and vice versa. A match of learning material to style should result in the most efficient learning.

Ford (1985) confirms the holist/serialist work with a small group of postgraduate students and discusses Pask's arguments with regard to comprehensive and operation learners. Comprehensive learners tend to act like holists under less controlled learning situations and operation learners like serialists. However, it is contended that to be successful students must become proficient at all styles and become what is known as versatile learners who are able to adopt different styles as and when required. It is perhaps surprising and of some concern that Ford's postgraduate students, who it is assumed are experienced and successful students, are not necessarily versatile learners in the sense of being able to learn equally well from both holist and serialist material. Entwistle, Hanley and Hounsell (1979) contend that to reach a full understanding of most academic topics both learning procedures have to be followed.

Experiential learning is a process whereby students learn by doing. *'One cannot learn a process or procedure merely by reading or hearing about it. We need to try it and, therefore, experience it.'* (Butler 1985). Students carry out learning activities and are then encouraged to reflect on these experiences in order to draw conclusions and develop theories that can be used in a new learning situation. They are further encouraged to reflect on their own personal experiences to make the learning personal so as to enrich the learning experience. *'Learning is the process whereby knowledge is created through the transformation of experience'* Kolb (1984). Kolb conceived an experiential learning model in which students follow a four stage learning cycle based on concrete experience (feeling), reflective observation (watching), abstract conceptualisation (thinking) and active experimentation (doing). This cycle is shown in figure 2.2.

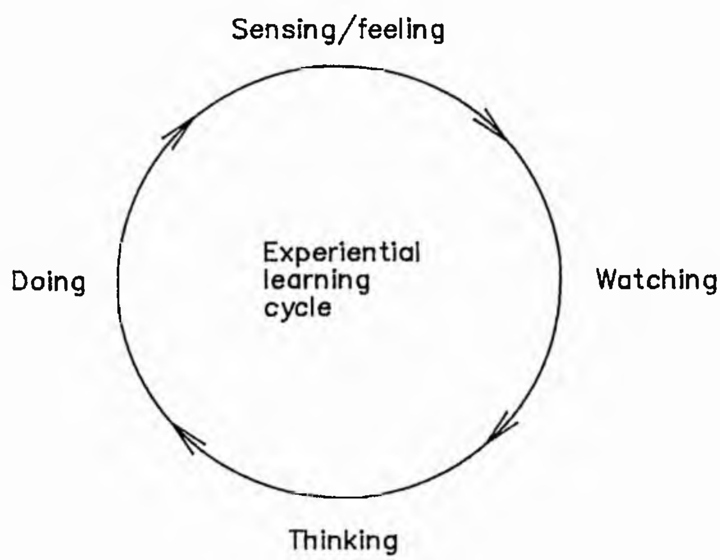


Figure 2.2 - Experiential learning cycle

Concrete experience involves a personal involvement that relies on feelings and intuitive thoughts that relate to specific experiences. Learning is facilitated by an immersion in the problem and relies more on intuition than logical analysis.

Reflective observation is based on watching and listening followed by careful reflection before taking action. Meticulous consideration of the previous experience is used to analyse the available information and to maximise personal understanding of this information.

Abstract conceptualisation is used to appraise the problem. Logic and ideas develop theories that model the situation to help the learner. This relies on intellectual understanding based on logical thought, modelling and systematic planning. It often involves formulating hypotheses to be tested in the next stage of the cycle.

Active experimentation applies the thoughts and ideas, developed in the previous stage, to practical problems. It is concerned with the practicality of the problem and learning is enriched by trying out ideas to see if they work in practice, or in amending theories to suit a practical situation.

Kolb uses a learning style inventory that consists of twelve items which are studied by the subject. The inventory includes self assessment against a set of personality criteria. A score for each identifies whether the subject is an accommodator, diverger, assimilator or a converger.

Accommodators benefit from practical experiences when learning and generally are good at getting things done. They tend to rely more on their intuitive response to a situation rather than to a logical analysis. Their learning preferences tend to lie between active experimentation and concrete experience on the learning cycle. *Divergers* are happier when they have to undergo a concrete experience and then reflect on this experience (feeling and watching). They tend to be good at recognising problems and generating alternative solutions. They can however have problems in synthesising these alternatives to arrive at the optimum. *Assimmilators* learn best in the areas of reflective observation and abstract conceptualisation. They are interested in developing theories, models and hypotheses rather than a practical solution to a problem. They are interested in abstract ideas and often have difficulty in applying their theories.

Convergers are strong in the thinking and doing parts of the cycle. They perform well when placed in a situation where they have to apply their ideas and theories to real problems. They are good at defining and solving problems and making decisions.

It can be argued that students learn best when the method is in accord with the preferred learning style, and that a mismatch between teaching and learning styles can hamper the learning process. However, as well as achieving academic excellence, students must be prepared for their future and become autonomous learners able to adapt and to take advantage of any learning situation. It is not sufficient to rely upon circumstances that suit their preferred style. Rogers (1983) aptly said that *'The only man who is educated is the man who has learned to adapt and change; the man who has realised that no knowledge is secure, that only the process of seeking knowledge gives a basis for security'*.

It should be realised that there are weaknesses as well as strengths to each of the stages in the learning cycle. Different students will feel happy at different stages in the cycle. Nonetheless, rather than devising a range of learning material to suit all of the different styles, it is preferable to subject all students to every stage in the cycle in order that students have the opportunity to exercise their strengths as well as to develop their skills in other learning situations. Stice (1979) in reviewing Kolb's learning style reports that learning is enhanced as more of the learning stages are used in the cycle, and that *'Left to their own devices students will do what is easiest for them, which is to use their own learning style'*. The experiential learning cycle is based on maximising the learning experience by creating material that takes students around the whole cycle, not necessarily concentrating on the strengths of the individual style but exposing the student to a variety of learning methods. Learning situations should, where possible, involve watching (lectures, demonstrations, etc), thinking about concepts, applying them to real problems and concrete experience using practical project work. Gibbs (1988) presents an overview of experiential learning based on Kolb's work. The material is recommended to the reader and includes practical advice on developing the techniques and material for *learning by doing*.

It is unrealistic to expect every learning activity to follow this model. However the model can realistically be applied in curriculum development, in particular during the planning and implementation of courses. Button, Jeffery and Swannell (1990) report on a new degree course, BEng Honours Integrated Engineering, in which students are subjected to a variety of learning experiences. The course involves substantially more continuously assessed and project work than is normally found in traditional engineering degree courses. The course was designed to incorporate the above learning cycle and other educational ideas. Felder and Silverman (1988) discuss learning and teaching styles in engineering education and conclude that the two are often incompatible leading to poor performance and that the inclusion of a number of the techniques outlined will meet the needs of most students. A teaching style that is both effective for students and comfortable for the teacher has a potentially dramatic effect on the quality of learning.

The 4Mat system (McCarthy, 1981), based on the Kolb learning cycle, accepts that there are four major identifiable learning styles, all of which are equally valuable. This system is aimed at schools and is built on the premise that pupils need to be taught in all four ways to be comfortable and successful for some of the time, whilst being stretched at other times to develop alternative learning abilities. Students working together will 'shine' at different places in the learning cycle and learn from one another. All four modes are used to provide a sequence of natural learning progression.

The 4Mat system is also extended to include techniques that develop and integrate the theories of 'right' and 'left' brain processing skills. This theory uses the hypothesis that the brain has two separate halves that process information in distinctly different ways. It is considered (Buzan, 1982) that the left side carries out linear sequential type processing, whilst the right side uses a global approach. It would appear from this that serialists are dominated by the left and holists by the right side of the brain. The 4Mat system proposes a learning model in which the pupil is subjected to experiences that develop both sides of the brain as well as utilising the four learning modes. The role of the teacher is constantly changing as pupils move round the learning cycle.

Learning styles preferences. *'Knowing about different learning styles preferences is the key to understanding and to becoming more efficient at learning from experience'* (Honey and Mumford, 1986a). The learning styles questionnaire developed by these two researchers requires a yes/no response to a variety of questions and is designed to provide a self assessment of the personal profile of the respondent. The inventory indicates four learning styles; activist, reflector, theorist and pragmatist. Their model, based on an experiential learning cycle involving four stages, see figure 2.3 below, has similarities to the Kolb model.

Each of the styles equips the learner to perform well at different stages in the cycle. Having strengths in all four styles provides the student with the best opportunity to benefit from a total learning process. Indications are that some 70 per cent of people have only one or two learning preferences. The best way to learn from experience is to develop learning styles in all four areas, and learning material should be produced to re-enforce individual learning strengths as well as to expose students to all four styles.

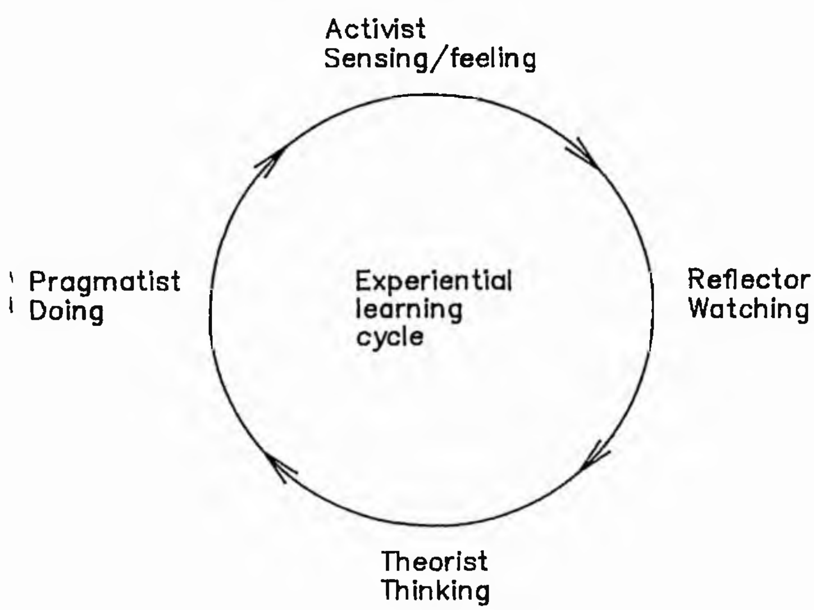


Figure 2.3 - Learning styles

Activists involve themselves fully in new experiences and enjoy the here and now. They are open minded and not sceptical and tend to act first without considering the consequences. They tackle problems by brainstorming, and seek to centre activity around themselves. *Reflectors* like to stand back to ponder experiences and observe them from many different situations. Thorough collection and analysis of data is important. They tend to listen to others before making decisions and their own points. When they act it is part of a wider picture that includes the past as well as the present and others' observations as well as their own. *Theorists* adapt and integrate observations into complex but logically sound theories. They think problems through in a systematic, analytical manner. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories, models and systems. *Pragmatists* are keen to see if something will work in practice. They seek out new experiences and take every opportunity to experiment with applications. They like to get on with things and act quickly and confidently with ideas.

The two learning styles questionnaires by Kolb and by Honey and Mumford perform similar roles in that they highlight the learning styles preferences of individuals. These styles can be related to an experiential learning cycle:

feeling - watching - thinking - doing	Kolb
activist - reflector - theorist - pragmatist	Honey & Mumford.

Both inventories provide a means of self assessment for students and the concepts within the inventory and the accompanying learning cycle can be used either by the student or the teacher. Students individual strengths are highlighted and they are made aware of study skills and the learning process. They are made to realise that they need to develop their learning methods to take advantage of all of the learning experiences that are available within a course. The teacher can use the concepts in curriculum development and in producing learning material.

The inventories both take 10-15 minutes to complete and provide a similar student profile, there being little difference in the usage of the end result. Honey and Mumford (1986b) provide advice in the form of a guide to learning styles and how to change the style. Their inventory is also easier to administer and more understandable to students. The main criticism of the Honey and Mumford inventory is that it was developed for use with professional people and students have difficulty in relating to some of the questions. It also relies upon yes/no answers with no opportunity for graded responses. However the simplicity of this inventory commends it to those interested in assessing student learning profiles.

2.1.6 Learning strategies

Learning strategy is concerned with the way that students choose to study a particular topic. This choice is often based on the perceived importance and relevance of the subject as well as their interests and their career and social aspirations. O'Neil and Child (1984) report Biggs as saying *'How we study is a function of why we study'*. Biggs (1978 and 1979) discusses three types of study processes and their effects on the quality of learning outcomes. The *reproducing* process is based on a fear of failure and relies upon rote learning using higher education as a means to an end. *Internalising* is based on an intrinsic motive in which wide reading takes place linked to meaningful learning strategies where the material is internalised and related to existing knowledge. Lastly *organising* is based on a strong desire to compete, to win and to excel in all studies. This results in a highly organised approach to study.

A student may find a certain subject uninteresting and feel that it is not particularly relevant to the course and his/her future career, in which case a reproducing or surface learning approach based on a fear of failure is likely to be adopted. This might not be sufficient to reach the minimum satisfactory level of achievement. An interesting subject with a clear link to a future industrial or commercial application is likely to be tackled with enthusiasm and result in total immersion in the subject, possibly to the detriment of other areas of the course. Both approaches can be dangerous and students need to be made aware of the problems so that they can develop suitable study skills and strategies that promote a deep learning process closely allied to the requirements of the course and to their assessment on the course. This is known as an achieving approach. The above approaches to learning; surface, deep and achieving respectively are clearly linked to reproducing, internalising and organising. They have been identified in several research studies (Biggs, 1987a, 1989; Entwistle, 1977; Entwistle and Ramsden, 1983; Watkins, 1983).

The study process questionnaire (SPQ) developed by Biggs (1987b) consists of a self assessment of 42 items and relates student learning motivation to learning strategy. Completion of the inventory provides information on students surface, deep and achieving approaches. Table 2.2 (reproduced from O'Neil and Child, 1984) outlines the motives and strategies that emerge from the SPQ.

Table 2.2 - Relationships between motive and strategy for Biggs' three dimensions

Dimension	Motive	Strategy
Utilising	*Instrumental:* Main purpose is to gain a qualification with pass-only aspirations. This is done as a means of obtaining a better job, more money, or some other extrinsic need.	*Reproducing:* overall, simply to avoid failure and specifically to focus on minimal content, primarily factual, as prescribed in class handouts, course outlines, etc., and to rote learn this necessary minimum for reproduction in examinations and/or assignments.
Internalising	*Intrinsic:* Study to actualise interest and competence in particular academic subjects and to develop special interests and abilities; studies are selected therefore that hold maximum intrinsic interest.	*Meaningful:* read widely and with maximum understanding (independently of course requirements), to integrate various subjects and make them personally meaningful.
Achieving	*Achievement:* to excel in studies as part of a general competitive approach to life and win high status thereby; more specifically, to study with a view to maximising grades awarded whether or not the material is interesting.	*Organising:* close orientation to course outlines, follow up all suggested readings, schedule time, behave as "model" student.

There are three distinct learning motives and three associated strategies. The utilising dimension has an instrumental motive that leads to a surface approach to learning with limited understanding and a recall of knowledge that is only sufficient to pass the next assessment. The opposite to utilising is internalising in which the student develops interests by reading widely and studying to achieve deep, meaningful, lasting knowledge and understanding. However, this approach can lead to concentration on narrow parts of the syllabus to the detriment of the course as a whole. Whilst it is desirable to encourage deep learning techniques using meaningful learning strategies, students should realise that a good grade in some subjects might not compensate for failure in others. The third motive is associated with achievement and results in a strategy that will give the best grade overall.

This last approach encompasses deep and surface learning when and where appropriate. The ability to recognise learning and assessment objectives and the ability to organise study to meet these objectives are important skills. However there is more to higher education than passing examinations and maximising grades. Students need to be given the opportunity to develop their interests within a structured environment. Swannell (1989) outlines one strategy adopted on an Integrated Engineering degree programme in which the core engineering subjects are examined, supporting subjects are continuously assessed and there is significant project based learning to allow students to develop. Early evidence of this course is that students are responding positively to this higher content of project work whilst still appreciating the benefits of more formal structured teaching techniques.

Lancaster studies. Entwistle, Thompson and Wilson (1974), in a study at Lancaster University relate academic motivation to personality and study habits and claim that personality and attitudes to study are closely linked. Four types of learner are identified being high and low achievers as well as over and under achievers. Extrinsic motivation, in which rewards external to the learning situation (i.e. bribes), is contrasted with intrinsic motivation in which the student derives interest in the task itself. This is elaborated (Entwistle 1975) to include student attitudes in a study of how students learn.

Five attitudes are recognised being:

disorganised and dilatory
cynical and disenchanted
syllabus free
fear of failure
competitive and efficient.

The first two attitudes are likely to result in a below average degree, the next two an average and the last category an above average degree.

A research programme is outlined by Entwistle and Hanley (1978) involving studies of the characteristics of students who adopt deep or surface processing strategies. An inventory to measure distinctive approaches to learning (Entwistle, Hanley and Hounsell, 1979) has been developed based on the earlier Lancaster studies and extended by the work of Marton (1976) and Pask (1976), on deep and surface approaches and comprehension and operation learning, as well as work by Ramsden (1979) and Biggs (1976 and 1979) on strategic approach and intrinsic/extrinsic motivation. This has subsequently become known as the Lancaster Inventory and identifies four main factors:

deep approach : comprehension learning
surface approach : operation learning
organised, achievement-oriented learning
stable extraversion.

Entwistle and Waterston (1988) report on a study to compare study style and strategy inventories derived from two different approaches. The first is based on anticipating study processes from experimental work in cognitive psychology. The second is based on qualitative analysis of student reports on their own study processes. A single inventory has been produced consisting of 30 items from each approach and a further 15 items to cover areas identified since the original inventories were devised, i.e. a total of 75 items. The areas covered are:

achieving - strategic approach linked directly to course objectives and vocational motivation

meaning - deep approach and intrinsic motivation

reproducing - surface approach linked to fear of failing

non-academic - disorganised study methods, negative attitudes and social motivation *deep processing* - critical analysis, conceptual organisation and comparison of information

elaborative processing - translation of information into own terminology, applications to personal experience and concrete examples

fact retention - learning facts and details

methodical study - activities contained in 'how to study' manuals.

Other learning strategies have been identified. In particular Marton and Saljo (1976a and 1976b) identified two levels of processing which they have called deep-level and surface-level processing. What the students learn is preferable to how much they learn. They discuss assessment methods related to processing levels and it is intimated that methods which rely on the regurgitation of facts will encourage students to adopt surface learning strategies, whereas assessment through techniques such as essays or oral tests result in deep learning. The deep and surface approaches are also mentioned by Svensson (1977) who argues that a deep approach is related to conscientious study and examination performance. Fransson (1977), contends that whilst interest in the subject encourages deep learning, a stressful learning environment produces more surface learning.

The above learning strategy inventories were designed with the objective of researching the correlation of study strategies with motives for learning, rather than as a self assessment. Biggs' 42 item study process questionnaire (SPQ) could be used by students to highlight their motives and strategies and to show that there are alternative ways of studying, and to encourage deep rather than surface techniques. Ramsden and Entwistle (1981) have also shown that the attitudes of teachers and the organisation of teaching and courses may affect students' approaches to learning. Their work, across 66 academic departments in higher education, show that departments with heavy workloads and a lack of freedom in learning had an emphasis on reproducing orientation. Conversely those that had good teaching and allowed freedom in learning showed a meaning orientation. Entwistle (1990), reporting on why students fail, relates that research suggests that it is essential for students to become more aware of their own learning strategies and to understand the implications of both deep and surface learning. The effect of student workload in pushing students towards surface techniques is also mentioned. Ince (1990) warns of the dangers of overloading students in killing imaginative thinking. *'In other courses the undergraduate is expected to think; in engineering, staying level with coursework is regarded as the sign of achievement.*

2.2 Artificial intelligence

2.2.1 General

'Soon after the invention of the first calculating machines, people were puzzled as they attempted to understand how machines can reproduce the behaviour of the human mind' (Dubas, 1990). Artificial intelligence (AI), a relatively new and rapidly evolving technique in the area of technology, is the latest attempt to develop the 'thinking machine'. Adler (1986) relates that AI originated from the *Turing test,* an imitation game for determining the intelligence of machines. It is reported by Teresko (1985) that the first AI program was developed in 1956 and the first knowledge based computer system in 1965. Another significant landmark in AI history is 1980 when the Japanese government initiated a programme to work with fifth generation computers in AI (Fisher, 1986). Rada (1990) reports that AI research in the United Kingdom during the 1970s was virtually terminated by the *Lighthill Report.* This report damned AI as a theoretician's toy containing little potential for the business world. This AI research was resurrected by the Alvey programme which was launched in 1983. This programme, sponsored by government, provides the opportunity for industrial firms and academics to collaborate in pre-competitive research and development in advanced information technology. A number of awareness clubs resulted from this initiative with the purpose of researching and promoting AI expertise and there is now a continuance of research in this area. A fuller discussion of the Alvey project is provided by Ray (1990). The need for the pre-competitive spirit of the awareness clubs developed within Alvey, is re-enforced by Cohen and Howe (1989) who argue that *'AI researchers must evaluate their work more thoroughly and report both the results and how they were obtained'.*

Within the continuing debate on artificial intelligence several different and sometimes contradictory definitions and explanations have been offered. *'The "discovery" of new technologies often give rise to misconceptions regarding their nature, use, and effectiveness'* (Fox, 1990). The following definition provides a useful basis for discussion.

> 'AI is a branch of computer science which deals with methods of problem solving by using techniques exhibiting human characteristics such as understanding language, learning, perception and reasoning. It deals with symbolic non-algorithmic methods of problem solving in order to represent, acquire and use knowledge to perceive, reason, plan, act and use language'. Kathawala, Elmuti and Timpner (1989).

Traditional computing is based on numerical computation and text handling using structured routines and algorithmic methods. AI uses heuristic methods in handling data and knowledge where more conventional approaches are unable to deal with the structure and uncertainty of the data. Heuristics programming establishes a set of heuristics or 'rules of thumb' with the aim of deriving an acceptable optimal solution to complex problems rather than an 'exact solution'. *'... both man and machine have to handle a number of sources of uncertainty and complexity* (Boyle, 1989). Computing is concerned primarily with *data processing* whereas AI is concerned with *knowledge processing*. Scott (1987) reports the *'knowledge industry'* as being the key component of the late 20th century society and states that knowledge and associated words are *'the accumulation of experience and experiment, and the technology to organise them, which so many argue is the engine that powers post-industrial society'*. If we are to grasp this concept of knowledge and use it to the benefit of industry and society then the appropriate AI tools must be developed in a systematic and coordinated manner.

The words Artificial Intelligence conjure up all kinds of mystique and to a certain extent fear of new technology within modern industry, which in the last two decades is just starting to overcome its technophobia. Chung and Inder (1990), in asking *why should engineers use AI,* aptly comment that 30 years ago they may well have been asking *why should engineers use computers*. As with the use of technology in general, it is hoped that AI will improve productivity and reduce costs. *'The central goals of AI are to make computers more useful (an* *engineering discipline) and to understand the principles to make intelligence possible'* (Stambler, 1985). In the software industry it is anticipated that AI will reduce the time taken for program development and ease the burden of software costs (Luchsinger, 1986). Computers are playing a significant role in engineering design and advanced manufacturing methods. The computing tools now available mean that a common product database is a reality for many organisations. This is resulting in the merging of engineering functions including design, development, manufacturing as well as sales and marketing. The resultant benefits of this concurrent engineering approach is likely to be furthered as AI is developed to augment the currently available tools. These systems are turning the 'factory of the future' into a reality (Koelsch and Manju, 1986).

2.2.2 Expert systems

Ignizio (1990) reports the AI community's definition of an expert system as *'a computer program that exhibits, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert'*. The emphasis within this definition is that the computer mimics the expertise of a human within a *limited and clearly defined* area of expertise. The domain is the specific area of knowledge of the human expert and the expert system simulates the reasoning within this area. A useful introduction and alternative definition of an expert system is provided by Leadbetter (1984), Waterman (1986) and Simons (1985).

It is not suggested that the computer and its software can be sufficiently advanced so as to think and act as a human being. As Gupta and Chin (1989) state *'human beings have an intuitive intelligence that reasoning machines or computer programs may not be able to match'*. Expert systems are *'not systems that are expert'* but are systems that mimic the expert. A complementary view of expert systems (Schreurs and Pessall, 1990) is that they *'mimic the human expert's high-level-inference patterns and can take advantage of the same "tricks of the trade".'* They are particulary useful in dealing with incompletely understood tasks and reasoning and '*provide one way to fill the "knowledge gap" between what problem solvers now know and what they need to know'* (Bouchard, Vadas, Kowalski and Lebensold, 1989).

A discussion of the pros and cons of expert systems is given by Miller and Walker (1988). The main advantages compared to the availability of human experts can be listed as:

- consistency of advice
- available at many sites simultaneously
- replicate the expertise of scarce experts
- de-centralises central knowledge
- can handle bewilderingly large amounts of data
- evaluate impartially
- able to explain their reasoning and decisions
- body of knowledge retained within organisation
- can operate cooly in hostile situations
- easily and efficiently updated and modified
- use explicit models for uncertainty
- not susceptible to illness, holidays or 'head hunting'.

As well as providing expert advice these systems have an important role to play in on the job training '*allowing a novice to learn how an expert works on a problem*' (Rychener, 1988).

As might be expected whenever advantages are claimed for a system there are disadvantages. Berry and Hart (1990a) put forward the interesting argument that repeated use of expert systems will change the ways in which problems are tackled, and that while it is hoped that this change will be beneficial, it may result in an over reliance on the system and in a deskilling of users. The same authors (Berry and Hart, 1990b) draw an analogy between this and the use of calculators. Some disadvantages of expert systems are listed:

- expensive to develop
- knowledge acquisition is difficult and time consuming
- only feasible for narrowly defined domains
- no general intuition or intelligence
- cannot exhibit 'common sense'
- do not readily adapt to change
- inflexible and unimaginative
- costs of hardware and software maintenance.

An expert system can never become better than the human expert that it mimics, and it needs to be maintained with up to date knowledge or else it becomes ineffective and potentially a liability. Devedzic and Velasevic (1990) discuss the shortcomings of first generation expert systems in dealing with conflicting information, time-varying knowledge and contradictory hypotheses.

When evaluating a project for the application of expert systems, as well as weighing the above advantages and disadvantages, the following criteria must also be met:

- the problem is well bounded,
- it requires non trivial reasoning and
- the solution brings identifiable benefits.

A detailed methodology for evaluating applications is provided by Laufmann, DeVaney and Whiting (1990). This incorporates numeric techniques to introduce objectivity into what is often a subjective decision making process.

An expert system often has the ability to self learn and to explain its reasoning. The main features of an expert system are the:

- user interface
- inference engine and
- knowledge base.

In order that the system can adequately emulate the human expert it must have a reliable and comprehensive knowledge base containing the facts and rules within the knowledge domain. The knowledge base is specific to the particular application and contains a set of empirical rules based on facts and heuristics. The knowledge is either represented by rule based or frame based methods or both. A rule based system uses IF condition THEN actions, whereas a frame based system uses networks in a tree type structure in which knowledge is contained at set points and relationships are stored linking this knowledge. A fuller description of these two types is provided by Friedland (1985). The knowledge base is the area in which the expertise is captured.

The inference engine determines how the knowledge base is to be accessed and processed dependent upon the goal that is to be met. Specifically it determines the order of processing of rules, which actions are to be performed and in what order as well as controlling the dialogue with the user. In processing the knowledge base a non-procedural process is used in which the order of handling knowledge depends upon the goal to be met rather than on a set order of statements defined by an external programmer. The inference engine decides on the knowledge required, obtains this knowledge from its knowledge base, uses rules to make inferences and reports its conclusions and reasoning. Forward and backward chaining is used within this inferencing. Pham and Tacgin (1991) provide a succinct explanation of this inferencing mechanism. Forward chaining searches the entire knowledge base for rules that match the known facts and actions these when true. The process continues until the goal is reached or there is no more information to search. Backward chaining starts from the ultimate goal and searches back through the knowledge base to find rules that allow this goal to be met. Modern expert systems use both types of chaining alternatively.

The user interface provides the links with the user and provides a 'friendly' means of obtaining information by asking questions, providing explanations when required and supplying conclusions and/or advice at the end of the consultation. Systems are now capable of interfacing with other software including other programming languages (pascal, C, etc), business and engineering software and with more conventional databases.

2.2.3 Expert system shells

Expert systems can be developed using conventional languages such as Fortran, Basic, Pascal and C, or by using special purpose languages that have been developed specifically for AI applications. The two most popular of these are Lisp, American based, and Prolog developed in Europe. A discussion of AI languages and software is provided by Deering (1985), Ramsay (1985) and Corlett (1986). The third alternative is to use a 'shell' approach which already contains AI methods and techniques for capturing knowledge and a standard inference engine to handle this knowledge. A detailed discussion of expert systems and shells is provided by Uzel and Button (1987).

Shells are less flexible and generally less powerful than using AI languages. However it is much easier to learn how to use a shell and this approach provides the non AI-programmer with a quicker and hence cheaper means of developing an expert system. Shells are available on a wide range of PCs and the desirable, as well as less desirable features, of these shells is discussed by Vedder (1989). It is claimed that it is easier to train an expert to use a shell than to develop the expertise of an AI programmer in the specialist domain (Johnston 1985). The time taken to elicit information from an expert is time consuming forming a major bottleneck in the development cycle. Advice on obtaining knowledge and the problems involved in this process are provided by Forsythe and Buchanan (1989) and by Mussi and Morpurgo (1990).

2.2.4 Expert systems as tutors

The use of computer based training (CBT), computer aided instruction (CAI) and computer aided learning (CAL) has been in education for a considerable time. It is thought to originate in the 1950s with simple linear programs influenced by behaviourist theories (Skinner, 1958). Kay and Warr (1962) reflected the optimism of the 60s in teaching by machine by saying that there is *'no room for doubt that programmed instruction can teach at least as well and as quickly as traditional methods'*. Whilst considerable advances have been made in these fields and some of the better packages serve to stretch the imagination of students, the techniques involved tend to rely upon the presentation of material with some testing involving feedback and possibly remedial work. Rathburn and Weinroth (1989) report that *'research in traditional CAI stagnated as practitioners became disenchanted with electronic page turners'*. A major drawback of CBT and CAL is the length of time it takes to produce effective courseware; Yazdani (1986) reports the view that an estimated 100 hours of development is required for each hour of courseware. This compares poorly with the ratio of two hours preparation that is generally accepted within higher education. Nicolson, Scott and Gardner (1988) suggest that *'the most serious challenge facing educational computing is the problem of producing quality software in sufficient quantity for educational needs'*. They propose an intelligent authoring system for CAL to help meet this need. Anderson, Boyle and Reiser (1985) claim that advances in AI and cognitive psychology can significantly reduce the time to produce educational software.

Laurillard (1977) recognises the advantage of using CAL to *'enrich the learning the student achieves from previous teaching by encouraging him to use his knowledge in a different way'*. Mitchell (1982) in discussing knowledge representation in CAL states that *'Successful teachers are flexible and able to respond with a variety of strategies'*. CAL tools often do not provide the same flexibility or the opportunity for interaction and processing of information nor do they cater for the individual needs of students with regard to prior knowledge and experience or for learning styles preferences and alternative learning strategies. As Yazdani (1988) states *'the traditional CBT strategy is learning by being told'*. The inference is that these techniques tend to promote surface learning strategies rather than the more effective deep and achieving learning strategies. As Hutchins (1968) states *'The mind is not a receptacle; information is not education. Education is what remains after the information that has been taught has been forgotten'*. The fear is that traditional CAL can be little more than a provider of information. More recent computing tools such as multi-media and expert systems allow for a number of different routes through the learning material and should be capable of supporting the individual needs of students. The improved quality of courseware and the potential for developing material in a shorter timescale may eventually overcome the prejudice that has developed against previous attempts to 'computerise' learning.

It should be recognised that teaching and learning is a complex process and whilst computers have an important role they are only one of many methods and are not a panacea for all learning. As in most aspects 'variety is the spice of life', and will generate the interest within education that is the key for effective learning. At present the most efficient use of computers within education is as support to other learning. In engineering education particularly, computers should pervade the whole of the course with both general purpose software (spreadsheets, word processing, etc) and specific applications such as computer aided design and finite element analysis tools being far more useful in developing student understanding as well as computer expertise. *'Computers can only be effective learning tools when integrated into a well designed course that is well organised'* (Button and Swannell, 1987). Whilst computer based education may have a part to play in higher education the idea of a 'course on a disk' is a dangerous concept that may well lead to surface learning rather than develop autonomous learning and other desirable deep learning methods.

One of the criticisms of computer based education is that systems are often developed by computer specialists and do not therefore incorporate sufficient educational concepts. Tompsett (1988) suggests that *'there are significant problems in the development of an intelligent tutoring system that can teach new concepts effectively'*, and the claims for such systems must be stated and then tested with input from the learners and teachers, not just the system developers. The use of expert system shells may in future allow the domain expert i.e. the teacher, to become more involved in the process of producing computer courseware. Carrier and Sales (1987) in presenting a taxonomy for the design of computer based instruction (CBI) argue for the inclusion of teachers on the courseware design team. Ok-choon Park (1988) concludes that AI provides an opportunity to advance knowledge of how to learn and teach and it is not sufficient to rely upon the increasing power of the computer to deliver instruction.

McCann (1981) identifies a difference between computer aided instruction (CAI) and computer managed instruction (CMI). Expert systems may well be better employed in computer managed learning (CML) rather than in computer aided learning (CAL), and be used for assessing the experience and knowledge of students and in providing advice and guidance on learning methods and strategies. Chan and Cochran (1988) contend that *'to give basic information to every new graduate student, a computerized expert system is vital'*. Hong (1989) argues that the use of expert systems to diagnose learner characteristics will help the teacher to structure the learning experience to support the strengths of students and the learner will *'become more and more interested and optimistic about learning'*. The use of AI for intelligent tutoring is at an early stage and there is a long way to go before it becomes an efficient and effective tool within the classroom.

2.2.5 Summary

The literature review has assisted in establishing the basis of the research and has resulted in a proposed learning model. As stated in the introduction to the thesis the model is not presented as the panacea for learning. It is proposed to promote discussion on alternative learning methods and to establish educational concepts that can be developed within higher engineering education. It is considered to be a useful aid to understanding student learning rather than as a definitive model to be adopted in every learning situation. The main object of the model is to promote debate on student centred learning and on self management of the learning process. The main elements of the model include educational aims and objectives, learning styles and strategies, assessment and experiential learning.

The development of the proposed learning model is presented and discussed in the next chapter. The medium/long term goal is to produce a knowledge based system that incorporates the learning model in such a way as to promote independent study methods. A strategy for developing this system is outlined in the next chapter.

Within this learning model two elements, learning style and learning strategy have been highlighted as two important areas of study. These are the main subject area of this thesis.

Chapter 3:

Proposed Learning Model

The only stupid question
is the unasked one.
Carl Rogers

Chapter 3 - Proposed Learning Model

3.1 Elements of the model

The importance of developing a student's spirit of independence for their approach to study is recognised by many within higher education. It is felt that students need to become autonomous learners able to benefit from and use learning opportunities in their future lives. Comenius, as early as the seventeenth century recognised the benefits of independent learning, in urging educators *'to seek and find a method by which the teachers teach less and the learners learn more'*. Within the Department of Mechanical Engineering at Nottingham Polytechnic the importance of giving the responsibility to students for their own learning is recognised and a number of initiatives have been created, both within the individual learning situation and the overall learning environment, to facilitate this process. Engineering undergraduate programmes are organised so as to shift the emphasis from teacher centred to student centred learning as the students progress to later stages of their course. This is achieved in the main through an increased use of assignments, case studies and projects; the final year of engineering degrees contains up to 50 per cent of this type of student activity.

The research reported in this thesis forms one element of the general policy to improve the learning environment and methods of study. As part of this research a learning model is proposed. The model is not presented as the panacea for learning. As discussed earlier the model is proposed to promote debate on learning methods and to establish and understand the educational concepts that are relevant to the research. Having proposed the model the intention is to produce a knowledge based system built on this model having the aim of managing the overall educational process by providing advice to students on general study habits and on particular learning tasks. The model was first presented by Button and Swannell (1987) and was further discussed at an Alvey Intelligent Knowledge Based System (IKBS) workshop (Button, Swannell, Uzel and White, 1987). The main elements of the model include:

- educational aims and objectives
- learning style
- learning strategy

- assessment, post and prior, with feedback
- experiential learning.

These elements have been outlined and discussed in chapter 2. The model, as proposed in 1987, is presented independent of subject material in figure 3.1.

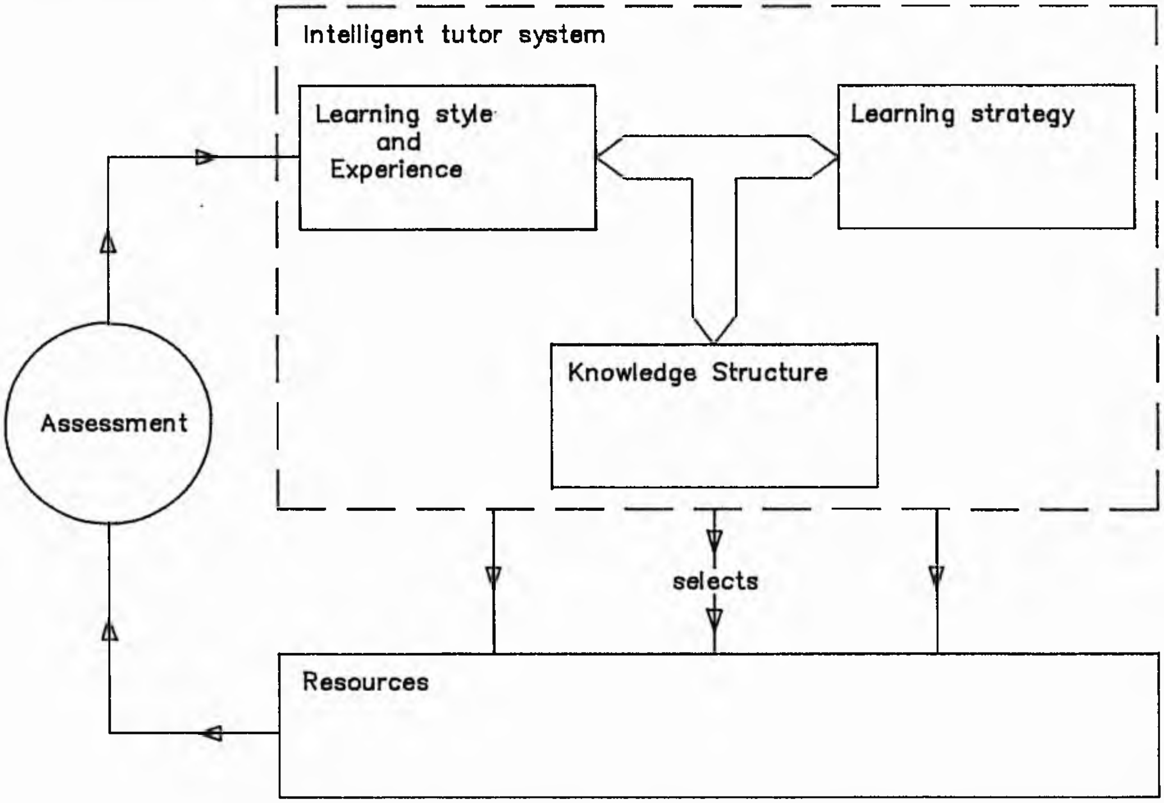


Figure 3.1 - Knowledge base: content independent

The philosophy of the intelligent tutor system is that students consult the knowledge base prior to, during and after the learning process. At the outset of their studies in higher education they obtain information on their preferred learning style and their existing learning strategies. Advice is given on using their learning style preferences, or more significantly, the importance of alternative styles and how to develop them. Students will only consult this part of the knowledge base at the outset of their studies and at fairly infrequent, albeit regular, intervals rather than every time a set piece of material is studied. The above model can be made content dependent, see figure 3.2, and be used with different subject material. It is intended that it be used in different settings to suit different requirements. For example it could be used to direct students towards a set piece of programmed learning text, incorporating a series of self assessment and terminal assessments, with the objective of providing students with a body of knowledge and/or skills in a specific well defined area. Alternatively it could be used to provide support to students carrying out project work by providing advice on the management and implementation of projects as well as directing students towards appropriate support material.

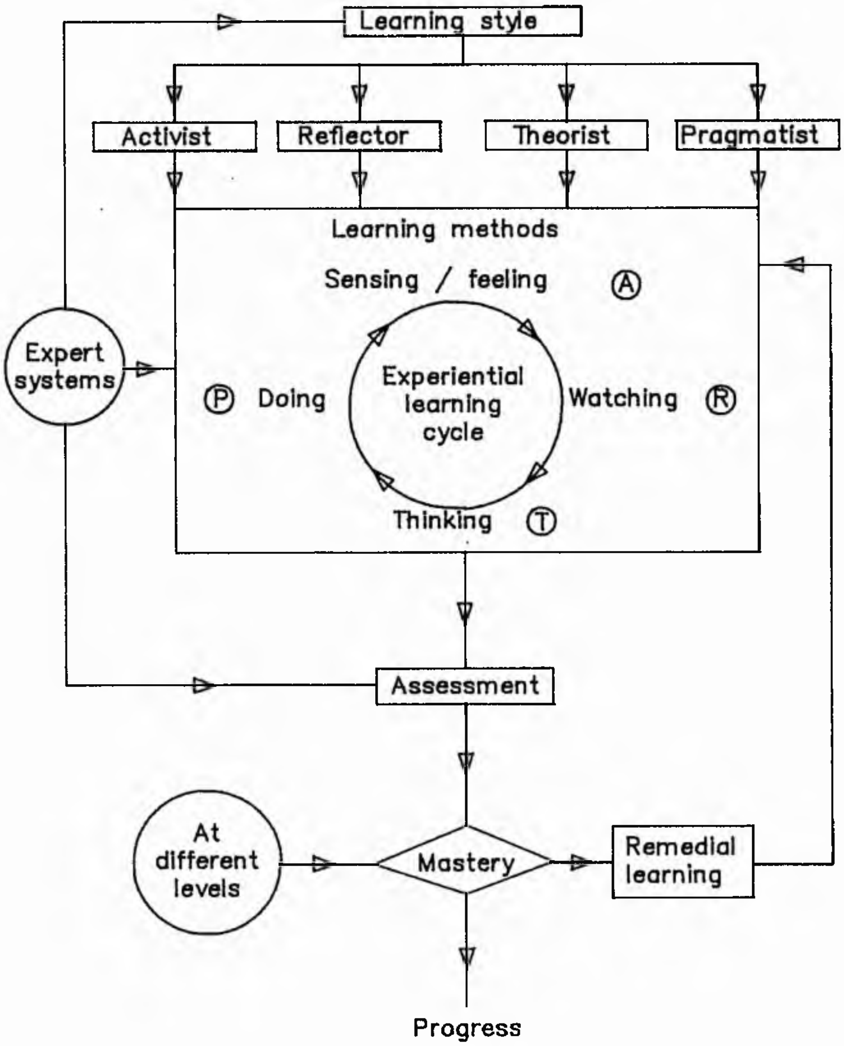


Figure 3.2 - Knowledge base: content dependent

It is proposed that the knowledge base will contain the general and specific learning objectives for the study material, based on the cognitive and affective domain using Carter's taxonomy. Students will therefore be alerted at an early stage to the required learning outcomes. Assessment will be provided both at the outset and at the end of a topic. Assessment of prior knowledge and associated advice from the system will guide students towards suitable learning at the appropriate level and stage. Terminal assessment, based on mastery learning when appropriate, will provide advice to students both on their performance and on remedial study that may be required. Where pertinent it is intended that learning material be based on the experiential learning cycle. However it may be more appropriate to incorporate experiential learning within the context of the whole course rather than in every single learning experience.

Elements of this learning model were also presented by Swannell and Button (1987), to the Standing Conference on Educational Development in Edinburgh. A general policy to provide learning opportunities and to improve the learning environment was reviewed at this conference based on:

- encouraging students to accept responsibility for learning
- developing learning skills in students for life
- encouraging independent and self learning
- instilling a thirst for knowledge
- providing problem solving and communication skills.

The role of lecturing staff as facilitators of learning rather than as 'teachers' was emphasised, with the main function being the management of learning resources for the benefit of students.

The concepts for the various components of the knowledge based system have been developed to produce a refined model from the above proposals. The basic components are the same as the earlier model, however the presentation has been altered to aid understanding of the process involved and the steps required to develop the system.

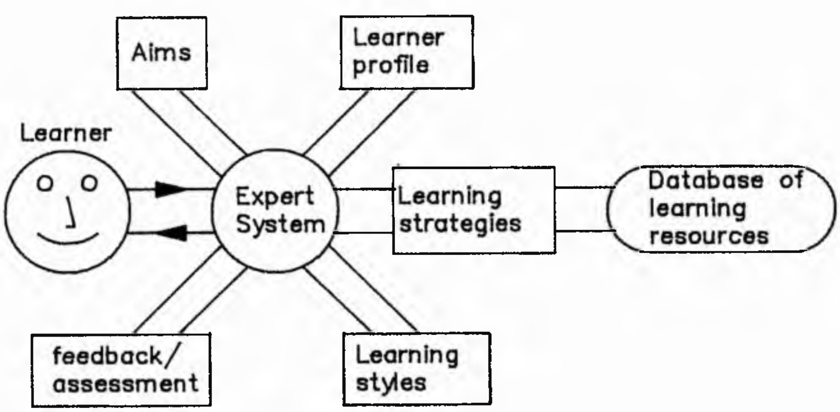


Figure 3.3 - Knowledge based system

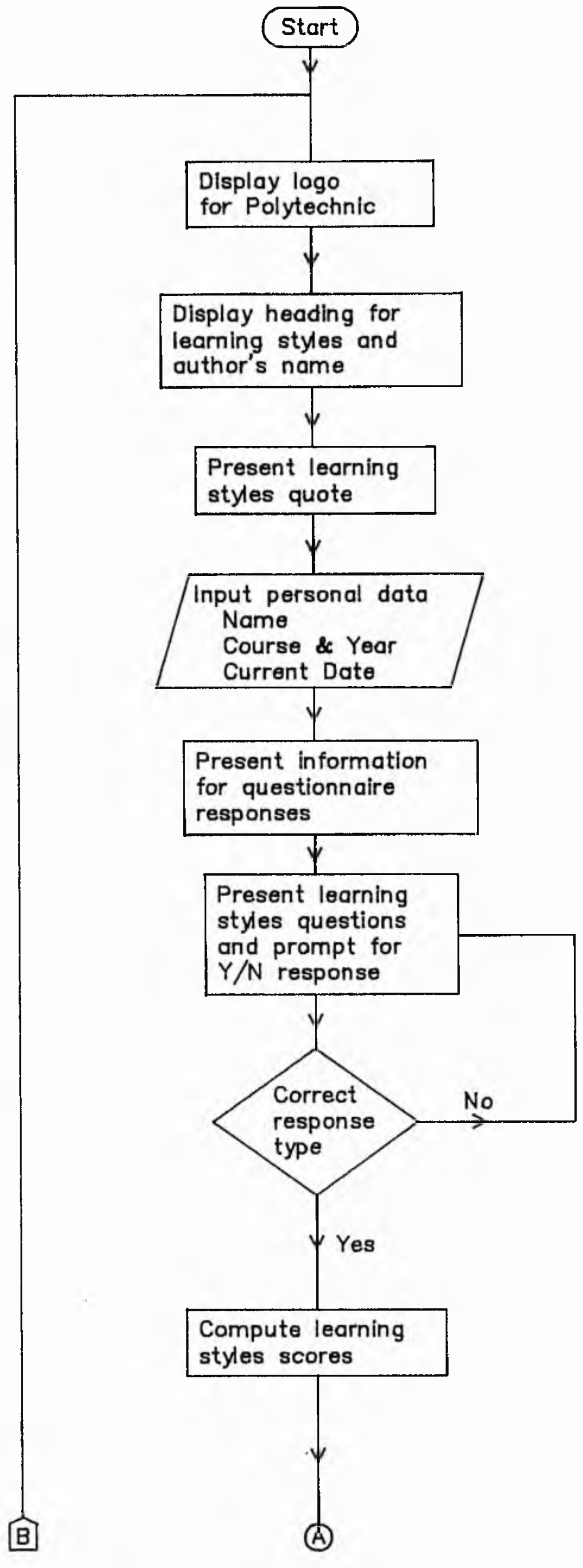
Figure 3.3 shows the current proposal, as discussed recently (Button and Swannell, 1990 and Swannell and Button, 1991).

The system consists of a number of distinct modules containing many of the ideas incorporated in the original model. The figure shows a central system that the learner consults. This acts as a central management system directing students to the appropriate module. Advice and guidance can be obtained from the learner profile and learning styles modules in order to assess the attributes, strengths and weaknesses that a student brings to the learning situation. Students are then directed towards alternative learning material held within databases, not necessarily computer based, via a module assessing and advising on learning strategies. The assessment module is provided to enable students to gain information on the prior knowledge of the subject, the goals to be met and the criteria to be used in assessment for grading. After the learning experience they can obtain assessment of their mastery of the subject and the need for remedial study. It is intended that academic staff use this module to assess student performance for grading purposes and to assess the effectiveness and shortcomings of the teaching and learning methods and of the subject learning material.

The development strategy for the system is to produce each module separately within its own 'expert system' shell and to bring them together at appropriate stages within the development cycle. To date two prototype modules are available. These are the learning styles module and an assessment module for student projects.

3.2 Learning styles

The research project has involved the development of a prototype system based on the Honey and Mumford learning styles questionnaire (LSQ). Details of the LSQ are reported later in section 4.2.1. The LSQ module has been developed within the LEONARDO expert system shell environment. This current section outlines the knowledge based system produced to allow students to obtain information on their preferred learning style. An overview of the learning styles module is given. This is provided in the form of flow charts, a description of the module as the user would experience it, followed by the main rule set of the knowledge base and a description of these rules. The various stages and the logic within the knowledge base are highlighted in the flow chart on the following figure.



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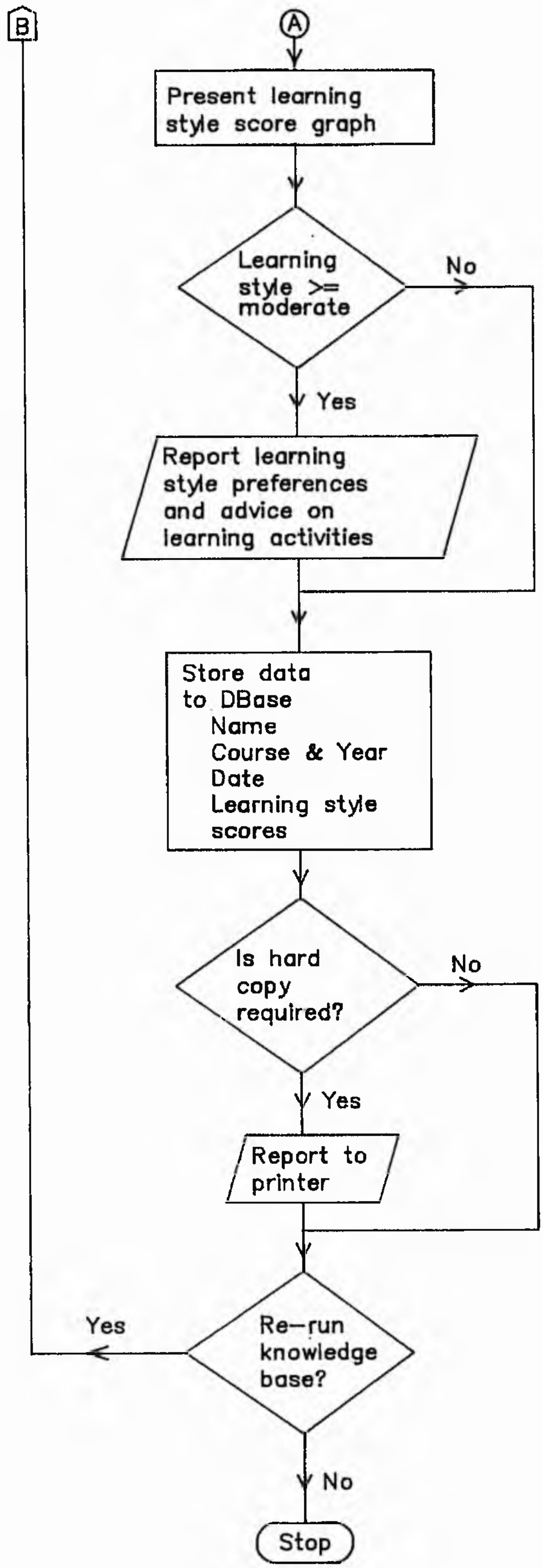


Figure 3.4 - Knowledge base flow chart

The system consists of four main sub-modules as listed below:

- initialisation
- knowledge gathering
- reporting on consultation
- data storage.

The user enters the initialisation stage of the module by typing RUN and pressing the RETURN key. The Nottingham Polytechnic logo is displayed and after a preset time a Learning Styles heading along with the author and authoring establishment is shown. After the prompt to press any key the following quote by Honey and Mumford (1986a) is presented.

> Over the years you have probably developed learning "habits" which help you benefit more from some experiences than from others. Since you are probably unaware of this, this questionnaire will help you pinpoint your learning preferences so that you are in a position to select learning experiences that suit your style.

The initialisation stage is complete at this point and the system moves on to collect data and knowledge about the user and the user learning style characteristics.

The next screen to be presented to the user requests input in the form of user name, course and year as well as the current date. Instructions on answering the questions in the learning styles inventory are then provided. This is followed by the individual questions of the Honey and Mumford LSQ. Users are prompted for a Y(es) or N(o) response. If an incorrect response is made an error message is presented and the user is given the opportunity to provide the correct response. At each stage the number of remaining questions is supplied. This forms the knowledge gathering stage.

At the end of the LSQ the scores and learning preferences are computed for each learning style. These scores are presented graphically on screen and, if required, as hard copy printout in the form of a learning style profile kite. The activist and theorist scores are plotted on the vertical axes and the reflector and pragmatist scores on the horizontal axes. Reports are then provided on screen for each of the learning styles providing the user obtains a moderate, strong or very strong preference. These reports consist of an explanation of the individual style and advice on learning activities for each of the styles. The learning styles scores and personal details are transferred to a datafile that can be used by the database software known as DBASE IV.

The user is then asked whether a hard copy of the reports is required. Finally the user is prompted for a request to either re-run the knowledge base or to exit the module.

The full listing of the rules and the objects of the knowledge base is extensive and it is not considered necessary to report the full knowledge base. Selected listings of rules, objects and procedures have been included in appendix 2 to highlight the structure of LEONARDO and the techniques used in developing the system.

The LEONARDO expert system shell used for the learning styles module is available throughout the Polytechnic, there being a site licence for unlimited use. It is used within the Department of Mechanical Engineering for undergraduate teaching, mainly within final year student projects, and is utilised for a number of research and other projects. The knowledge base for the LSQ module, see appendix 2, consists of a main rule set and some 55 objects. These objects contain frames that hold additional information such as screen designs and procedures. LEONARDO has good screen presentation functions including graphics that considerably enhance user interaction and help in the aesthetic presentation of the expert system. As well as representing 'expert' knowledge the shell has the ability to expand on requests for user information, to generate reports to the user and to explain why a particular decision has been made. The main rule set is the control section of the program. This main rule set is listed below to illustrate the overall structure of the knowledge base and to demonstrate the structure rules within LEONARDO.

Learning Styles Inventory : Knowledge Base

```
***** Main Rule Set *****
/*  Program Name: LSI1
/*
/*  Author:        M J Swannell
/*
```

```
/*  Address:       Nottingham Polytechnic
/*                 Department of Mechanical Engineering
/*                 Burton Street
/*                 NOTTINGHAM
/*                 NG1 4BU
/*
/*  Telephone:     (0602) 418418 Ext 2331
/*
/*  ==================================================
/*
/*  --------- LEARNING STYLES INVENTORY --------
/*            ========================
/*
/*  Runtime controls
       control private

/*  Set goal
       seek learning_style

/*  Obtain current date, display banner
/*  opening credits and obtain user data
       if heading is 'Nottingham Polytechnic'
       then run proc_date(curr_date);
            run screen1();
            run proc_banner(heading);
            use opening_credit;
            use opening_statement;
            use user_input_screen

/*  Initialise learning style scores
       if query is start
       then activist = 0;
            theorist = 0;
            reflector = 0;
            pragmatist = 0;
       preference is LOW

/*  Start consultation through object "proc_questions"
/*  End consultation when "learning_style" is known
/*  and display report to user
       if start is yes then
```

```
            run
        proc_questions(heading,question,style,activist,theorist,
        reflector,pragmatist,ques_no);
            run
        proc_style_graph(activist,theorist,reflector,pragmatist,
        surname);
            hold;
          graph is done

/* Determine which reports to display to user depending on score

          if activist > 6 then
            run proc_preference(activist,6,10,12,preference);
            use act_scrn1;
            use act_scrn2;
          act_result is done

          if theorist > 10 then
            run proc_preference(theorist,10,13,15,preference);
            use the_scrn1;
            use the_scrn2;
          the_result is done

          if reflector > 11 then
            run proc_preference(reflector,11,14,17,preference);
            use ref_scrn1;
            use ref_scrn2;
          ref_result is done

          if pragmatist > 11 then
            run proc_preference(reflector,11,14,16,preference);
            use pra_scrn1;
            use pra_scrn2;
          pra_result is done

/* Write results down to database file "lsdata.dbf"

          if ques_no > 40 then
           run
        proc_database_save(activist,theorist,reflector,pragmatist,
        course_year,surname,course,curr_date);
```

```
          data is done

/* Determine whether print hard copy report is needed.
/* Decision is found using screen conc_scrn.

if activist>6 or theorist>10 or reflector>11 or pragmatist>11
      then
         use conc_scrn;
condition is done

if activist<7 and theorist<11 and reflector<12 and pragmatist<12
      then
answer is 'n'

/* If hard copy required procedure "proc_hard_copy" is executed

       if answer is 'y' then
         run
    proc_hard_copy(activist,theorist,reflector,pragmatist);
       hard_copy is known

       if answer is not 'y' then answer is 'n'

/* Set up cycling of knowledge base and query stop or continue
/* with a new run. Maximum number of cycles is defined by
   numeric object
/* cycle_limit currently set at 10

       use rerun_scrn

       IF start is yes then cycle_limit=10

       if cycle is STOP
       then cycle_mode is stop;
            learning_style is known

       if cycle is RERUN
       then cycle_mode is autocycle;
            learning_style is known
```

Comments are included in the listing to provide embedded documentation to enhance understanding. These comments are identified by starting a statement with the /* characters. The first 18 statements are all comments; these being followed by the 'control private' statement that protects the contents of the knowledge base, from user interference, in the run time version. The next statement initialises the knowledge base and starts the search to find the goal of this module, which is to determine the learning style preferences of the user.

The next set of statements run various graphics procedures that present the opening logo, credits and LSQ quote before presenting the user with the data input screen. The learning style scores and the value of the preferences are then initialised at 'zero' and 'low' respectively before the consultation is started. A procedure called 'proc_questions' is initiated to present the LSQ which is followed by a procedure that presents the results of the learning styles scores in the form of a graph on the screen. The statements on lines 55 to 77, of the main rule set, call procedures to obtain the learning style preferences when the scores are greater than 'low', i.e. score for activist > 6, theorist > 10, reflector > 11 and pragmatist > 11. A report is also generated for each style if any of the learning style preferences is greater than 'low'. For score values less than these criteria then the initialised value of 'low' is used as the default value and reports are not generated.

The next statement fires, i.e. calls and starts, the procedure 'proc_database_save' when all of the questions in the LSQ have been answered. This procedure writes the learning style scores and personal data to the file 'lsdata.dbf' in a format that is suitable for interrogation by database software known as DBASE IV. The next set of statements, lines 89 to 91, present a screen to determine whether the user requires a hard copy. However this is only presented if one or more of the learning style scores is greater than the 'low' preference criterion. If the user responds positively the procedure 'proc_hard_copy' sends the appropriate reports to a printer. If all preferences are 'low' or the user responds negatively then reports are not generated.

Finally a set of statements present a screen to determine whether the knowledge base is to be re-run. The maximum times that the module can be re-run is set at 10. The various text based procedures, mentioned above, are listed in detail in appendix 2. Procedures, mainly screen presentations, involving numeric code have not been included as they do not add to the clarity of understanding of the knowledge base.

An early version of the knowledge base has been used as a staff development exercise by academic staff within two seminars run by this author during 1990. The seminars were provided to raise the awareness and promote discussion amongst academic staff of learning styles and their relevance both in the individual learning situation and within a course. The seminars also helped to test the knowledge based module. Pilot trials have also been run with a sample of students to test the software. This usage enabled an error free version to be developed in a form suitable for research into student learning styles.

The current module is available as a run-time version. A run time system consists of the final knowledge base and is run independently of the LEONARDO development system. Users are unable to gain access to the editing and development tools of LEONARDO and the module can therefore be used as a system protected from interference and misuse by users. It is isolated from the main LEONARDO development environment. This allows users to run the system from a single disc using an IBM or compatible personal computer with the advantage that it is unnecessary to purchase separate LEONARDO development shells to run the LSQ module. The run time system can be copied to any number of discs and run independently. Although this run time system is capable of being run from a single floppy disc, its performance is considerably improved if installed on a hard disc machine.

3.3 Project assessment

A module on feedback and assessment, started by Button and Uzel (1988) using an expert system shell known as SAVOIR, is aimed at providing advice on the assessment of student projects. This module has been further developed by the Knowledge Systems Centre at Nottingham Polytechnic using the LEONARDO shell (Gentle and Button, 1990 and Gentle and Blakey, 1991).

Typically, individual major study projects form some 15-20 per cent of a student's workload within the final year of engineering degree courses in the UK. This is augmented by other group or individual projects both in the final year and in earlier years. If anything the contribution of this type of student activity towards the final grade will increase in the future. Its importance will therefore become enhanced and there is a need to provide quality advice to students that allows them the opportunity to maximise their performance on projects. There is also the need to provide guidance to new academic staff members who in all probability will have little experience in assessing project work.

The Project Assessment Knowledge System (PAKS) has been developed to meet both the requirements of students in carrying out projects, and of staff in assessing projects. The knowledge base uses a set of guidelines published by the Council for National Academic Awards (1989b) which are based on a survey of current practice in the UK. The source of the knowledge is therefore well founded and documented and represents the best practice currently available. Two prototype versions are available, one for students and the other for academic staff.

The final student version will be capable of consultation at a number of stages. At the outset students will obtain guidance on the area in which they are to be assessed and the criteria to be used in their assessment. They will also be able to consult throughout the project to check on their progress, and finally they will be able to consult the system immediately prior to submission of their thesis. Students will be able to obtain an assessment of their performance and likely mark, and be able to make a final effort to improve their work if this is considered necessary.

The second complementary version, known as THESYS, is being developed to facilitate commonality in marking for moderation purposes and to assist the novice supervisor. There is also a role for this version in staff development for the purposes of project assessment and for course development. Decisions on the relative importance of projects as well as the criteria and associated weightings to be adopted within their assessment will be facilitated.

Chapter 4:
Research Methodology

Experience without testing is anecdote
and theory without testing is speculation.
C Hanby

Chapter 4 - Research Methodology

4.0 General

The aims, objectives and the hypotheses to be tested are set out in the introduction of chapter 1. The objectives, repeated below for the convenience of the reader, are to:

determine the learning strategies and learning styles of a representative sample of second year engineering degree students;

compare these strategies and styles with published data from previous studies by other researchers;

confirm the previously determined relationships among learning strategies and learning motives;

investigate the relationships among different learning styles and between learning strategy and learning style;

investigate the relationships among learning strategies and learning styles of students with their performance on continuously assessed work and examinations;

compare the learning strategies and learning styles of full-time and part-time students.

In order to meet these objectives it was necessary to determine the learning strategies and learning styles of a representative sample of engineering students. The student sample is discussed in chapter 5.

A range of inventories that can be used to determine learning strategies and styles are outlined and discussed in chapter 2. The inventories selected for the research are the Biggs Study Process Questionnaire (SPQ) and the Honey and Mumford Learning Styles Questionnaire (LSQ). These inventories are relatively uncomplicated and were selected as being appropriate for this particular study and for their ease of understanding by students and for the ease of administration. For the convenience of the reader the two questionnaires are reproduced in appendix 3.

All of the students in the sample completed the questionnaires at the start of their second year of studies. In order to test the hypotheses concerning correlations between learning strategies and styles with student performance it was necessary to obtain information on assessment marks. This information was gained from the examination boards at the end of the academic year.

4.1 Learning strategies inventory

4.1.1 Biggs' SPQ

The inventory selected for the research into student learning strategies is the Study Process Questionnaire (SPQ) developed by Biggs and fully described in his SPQ Manual (1987b). The SPQ is designed to assess the learning motives and strategies adopted by students in higher education. The approach to learning can be considered a composite of the motives and strategies described in table 4.1 below (reproduced from Biggs, 1987b). Approach to learning has an important bearing on student progress and may be a critical factor in the quality of learning and in student achievement.

The questionnaire consists of 42 items and gives three scores on motives and three scores on strategies, i.e. there are six components with seven questions for each. Respondents are asked to study each item and then record their score from 1 to 5 on a separate answer sheet. The scores correspond to responses of *never true, sometimes true, true half the time, frequently true* and *always true* respectively.

The SPQ manual provides advice on how SPQ scores can affect teaching decisions and also how they can be used in the counselling of students. However within this project the scores have been used as a research tool to obtain data and comparisons between student groups and to investigate correlations with other factors including learning styles and student performance. A discussion on the use of the SPQ in teaching and counselling has not therefore been included.

Table 4.1 - Student approaches to learning

Approach	Motive	Strategy
SA: *Surface Approach*	**SM:** Surface motive is to meet requirements minimally; a balancing act between failing and working more than is necessary.	**SS:** Surface strategy is to limit target to bare essentials and reproduce them through rote learning.
DA: *Deep Approach*	**DM:** Deep motive is intrinsic interest in what is being learned; to develop competence in particular academic subjects.	**DS:** Deep strategy is to discover meaning by reading widely, inter-relating with previous relevant knowledge, etc.
AA: *Achieving Approach*	**AM:** Achieving motive is to enhance ego and self-esteem through competition; to obtain highest grades, wheth-er or not material is interesting.	**AS:** Achieving strategy is to organise one's time and working space; to follow up all suggested readings, schedule time, behave as 'model student'.

4.1.2 Reliability and validity

Evidence on the reliability and validity of the SPQ is provided in Biggs' manual. Two indices of reliability are discussed. The first index, test-retest reliability, gives an indication of the stability of the inventory by comparing a group of individuals' scores when the test is repeated after a short period of time. Identical results would indicate reliability. Changes in students characteristics and learning habits could however genuinely alter their motive and strategy scores thereby causing differences in the re-test values. A move away from surface approaches would be encouraged and might even be expected in higher education. The SPQ manual provides evidence on this aspect of reliability indicating reasonable stability of Biggs' Learning Process Questionnaire (LPQ), a similar instrument to the SPQ.

Internal consistency is the other type of reliability. It is reasonable to expect students to give similar scores in response to the seven questions attributable to a particular motive or strategy scale i.e. questions 1, 7, 13, 19, 25, 31 and 37 regarding surface motive. This can be measured using Cronbach's alpha coefficients from factor analysis of the raw data. A coefficient lower than 0.4 suggests a scale that reflects more than one underlying factor. The alpha coefficients are reported as being satisfactory by Biggs in the SPQ manual with the surface motive being least satisfactory. The alpha coefficient reported for the surface motive is 0.51. O'Neil and Child (1984), based on a sample of 245 UK polytechnic students, concluded that the surface motive was the weakest but the other five motive and strategy scores were favourable. Hattie and Watkins (1981), following a study of the reliability and consistency of the SPQ with 255 Australian university students, *supported the validity of Biggs' model of the study process domain*.

Validity is a measure of the extent that the instrument measures what it is designed to measure. Construct validity relates the scores of the instrument to other factors. It is reasonable to expect high scores in the deep and achieving strategies to be related to performance when carrying out high quality and detailed student engineering projects. If a good correlation is found between these factors this would confirm the validity of the SPQ. Whereas a high surface strategy associated with a good performance would indicate that the surface scale scores were not measuring what they are supposed to measure, which is the reproduction of facts.

Evidence within the SPQ manual illustrates that the scale scores relate to student performance in consistent and predictable ways. The evidence provided suggests that the Biggs SPQ is satisfactory for research into learning motives and strategies, and provides a suitable instrument for the research project reported in this thesis. Factor analysis of the data collected for the research reported in this thesis confirms the above evidence with regard to internal consistency of the SPQ. Details of this analysis is reported in section 6.1.3.

4.1.3 Administration and scoring

The questionnaire was presented to large groups of second year engineering degree students with an explanation that it was being administered as part of a research project into student learning processes and with a request for their co-operation. Students were instructed to place their name and course on the answer sheet, however assurance was given that their answers would be treated in confidence and results would only be published anonymously. In order that the student responses were not influenced no further verbal instructions were given or discussion held with students.

The questionnaire is forwarded by an introduction explaining that there is no right way to study and that study techniques depend upon an individual's style and the particular course of study. An explanation is made that the questions are selected to survey important aspects of study in higher and further education in order to obtain information of study attitudes and processes. The importance of answering every question is emphasised and the confidentiality of the questionnaire is re-enforced. Finally, instructions are provided to help students complete the questionnaire.

The questionnaire is organised such that the six items are cycled in the order of surface motive, deep motive, achieving motive, surface strategy, deep strategy and achieving strategy. Organisation in this manner considerably aids hand scoring without decreasing the reliability of the results of the survey (see SPQ manual). The range of score for each motive or strategy is therefore 7 to 35. In order to make sense of individual and group scores a series of motive and strategy norms are published in the SPQ manual. These norms, based on a total sample of 2402, are available for male and female university students and are categorised into faculties of arts, education and science. The norms are arranged in deciles. A student is said to be 'above average' and designated '+' for a particular motive or strategy if the percentile score is 71 to 100, 'average' (0) for a percentile score of 31 to 70 and 'below average' (-) for 30 or less. A student scoring within the 70 (or above) percentile in the deep motive and strategy scales would therefore be categorised as having a deep approach to learning. The norms, based on the sample of 2402 respondents, are reproduced in table 4.2 below.

Table 4.2 - Learning strategy and motive norms

	below average	average	above average
surface motive	7 - 19	20 - 24	25 - 35
surface strategy	7 - 18	19 - 23	24 - 35
deep motive	7 - 19	20 - 24	25 - 35
deep strategy	7 - 19	20 - 24	25 - 35
achieving motive	7 - 17	18 - 22	23 - 35
achieving strategy	7 - 17	18 - 23	24 - 35

4.2 Learning styles inventory

4.2.1 Honey and Mumford LSQ

The inventory selected for the research is the Honey and Mumford Learning Styles Questionnaire (LSQ) (1986a and 1986b). The original questionnaire contains 80 items and respondents have to decide whether, on balance, they agree or disagree with the item. The majority of questions are behaviourial in that they seek to determine how the respondent would react in a given situation. Some of the items do however probe a preference or belief. The LSQ is designed to discover general trends or tendencies of the respondent.

A shortened version of the LSQ, which in the main is a subset of the full questionnaire, has been produced. Use of this latter questionnaire has been observed to produce statistically the same results as the full questionnaire (Honey and Mumford, 1986a and Mumford, 1991; private correspondence). The LSQ is designed to determine four learning styles preferences; activist, reflector, theorist and pragmatist. The following short descriptions are given by Mumford (1987).

Activist dominated by immediate experiences and revelling in firefighting.

Reflector likes to collect data and analyse it before coming to any conclusions.

Theorist is keen on basic assumptions, theories and models.

Pragmatist likes to search out new ideas and to experiment with applications.

The Honey and Mumford LSQ and the associated four styles are discussed in greater detail in chapter 2. The shortened version has 40 questions, 10 for each of the four preferences. This shortened LSQ has been utilised for the research into student learning styles.

4.2.2 Reliability and validity

Evidence of the reliability and validity of the LSQ is provided in the Manual of Learning Styles (Honey and Mumford 1986a). The reliability was confirmed from tests in which 50 people repeated the questionnaire after a two week gap. The correlation was found to be 0.89 (Pearson's product-moment coefficient). Correlations for each preference were:

activist => 0.81
reflector => 0.92
theorist => 0.95
pragmatist => 0.87.

These correlations are high showing a very strong relationship between the original and the repeated tests. As such the reliability of the LSQ is considered to be satisfactory for research into student learning style preferences.

The LSQ has been administered to more than 1500 people. Whilst specific validity tests have not been carried out, its validity has been checked on courses by making specific behavioral predictions (Honey and Mumford, 1986a). The predictions have been found to be largely accurate such that the face validity is not in doubt. The widespread use of the LSQ has not resulted in major disagreements that could not be resolved after further explanation.

4.2.3 Administration and scoring

The questionnaire was presented to large groups of second year engineering degree students at the same time as the learning strategy inventory with the same explanations. Again assurances were given about the confidentiality of the responses. In order that the responses were not influenced no further verbal instructions were given or discussion held with students.

As well as the learning styles module discussed in chapter 3 the LSQ can be administered using a text based questionnaire. The questionnaire is organised such that there are ten questions that are relevant to each of the four styles. The questions are presented in a random order to discourage the respondent from recognising a particular pattern and biasing answers accordingly to produce spurious results. At the end of the questionnaire the positive responses are totalled to obtain a score for each learning style preference. With the shortened LSQ these scores are doubled to correspond with the full LSQ. This process is automatic with the learning styles computer module in which a summary of the results is passed to a database file.

The learning styles preferences and advice on learning activities is available to students after completion of the LSQ. These preferences are categorised into *very strong, strong, moderate, low* or *very low*. The category is obtained by comparison with standard norms for each preference obtained from a sample of 1302 people in UK industry. The learning preferences and associated norms are calculated on the scores obtained by taking the percentiles as indicated below.

Very Strong - the highest 10 per cent of the sample
Strong - the next 20 per cent
Moderate - the middle 40 per cent
Low - the next 20 per cent
Very Low - the lowest 10 per cent of the sample.

The norms for each style are shown in table 4.3 below. It is worth noting that each style preference has a different range of scores for the five categories, i.e. a score of 13 would rate as very strong in the activist style but only moderate in the theorist style. This reflects the actual scores from the sample of 1302 respondents.

Table 4.3 - Learning style preference norms

	Very strong	Strong	Moderate	Low	Very low
ACTIVIST	13 - 20	11 - 12	7 - 10	4 - 6	0 - 3
REFLECTOR	18 - 20	15 - 17	12 - 14	9 - 11	0 - 8
THEORIST	16 - 20	14 - 15	11 - 13	8 - 10	0 - 7
PRAGMATIST	17 - 20	15 - 16	12 - 14	9 - 11	0 - 8

4.3 Statistical analysis tools

4.3.1 SPSSX statistics computer package

The research involved large quantities of data collected on students' learning strategies and styles associated with their performance in various elements of assessment within courses. In order to handle this data and to carry out the necessary statistical analyses it has been essential to employ a statistics computer package. The software utilised is the SPSSX package. SPSSX can perform many types of statistical analysis and data management and is used widely both as a research tool and for undergraduate teaching. The standard statistical techniques and their use within SPSSX is described by Norusis (1987). SPSSX is available on the Polytechnic mainframe computer and is a relatively straightforward, although powerful, package to learn and use.

The package provides a means of summarising data held within a conventional text datafile and provides standard statistical reports including sorting, mathematical manipulation and listing of data, and is also capable of plotting histograms, normal distributions and cumulative frequency charts. Analysis of data to determine means and standard deviations can readily be carried out as well as hypothesis testing including t-tests and chi-square tests. Furthermore the standard analysis within the package includes the investigation of relationships between two variables using regression analysis with associated plots and the determination of Pearson coefficients to test correlations. Most of these standard techniques have been used in analysing the research data and in investigating relationships between the variables on student learning processes and assessment performance. Advanced use of SPSSX involves multivariate statistical techniques to determine relationships between more than two variables. One technique is factor analysis which has been utilised for the analysis of student responses to Biggs SPQ. Factor analysis is discussed further in section 4.3.2.

In order that SPSSX can analyse data it is necessary to issue the package with a series of commands. Commands are normally accompanied by information in the form of keywords that modify the behaviour of the command. Commands are used to identify the file containing the data, to specify how the data is to be read and interpreted and to indicate what is to be done with the data. These are relatively simple to understand and an inspection of a list of commands will normally illustrate the analysis that is to be performed. The following, which provides plots and correlations of learning strategies against motives, displays the structure of a typical command file. The name of the file is **STRPLOT.SPS**. STRPLOT denotes the file and the SPS file extension identifies the file as an SPSSX command file.

```
***** STRPLOT.SPS *****
FILE HANDLE STRAT / NAME='STRAT.SYS'
GET FILE=STRAT

VARIABLE LABELS  SS 'Surface Strategy'   SM 'Surface Motive'
                 DS 'Deep Strategy'      DM 'Deep Motive'
                 AS 'Achieving Strategy' AM 'Achieving Motive'

PLOT HSIZE = 60 / VSIZE = 30 /
    HORIZONTAL REFERENCE(19,25) / VERTICAL REFERENCE(20,25) /
    FORMAT=REGRESSION
    PLOT=SS WITH SM
    PLOT=DS WITH DM
    PLOT=AS WITH AM
```

The first two commands identify the file holding the data, STRAT.SYS, and opens this file for use by the remaining commands. Next are descriptors for the six variables SS, SM, DS, DM, AS and AM. These descriptors appear on output listings and plots. The next command, with its keywords, sets the size of plot and the range for the x and y axes and draws horizontal and vertical lines denoting the demarcations for high and low scores for the strategy and motive respectively. Finally the plotting routine of SPSSX is initialised. In addition to the graphical plots, this routine carries out regression analysis of the two variables and a correlation of the strategy and motive variables.

The command files used in the research were created using a word processing package on an IBM PC. The resultant file was then transferred to the mainframe computer using the KERMIT communications package. The SPSSX package was invoked interactively for each of the command files using the VAX/VMS command SPSSX <command file>.

i.e. SPSSX STRPLOT

The default setting is for all output to be sent to the screen. In order to obtain a hard copy of the results it is necessary to switch on the plotter to obtain a mimic of the screen as the package runs.

4.3.2 Factor analysis

The Biggs SPQ contains 42 items. The SPQ aims to determine the six behavioral patterns of surface, deep and achieving learning related to student motives and strategies. Clearly there must be sub-sets of the 42 items that are related to a single motive or strategy. As might be expected the SPQ has seven questions for each of these six factors. It is implicit within the SPQ that seven questions are grouped to represent each single factor, i.e. seven specific questions refer to surface strategy. A student with a particular learning strategy or motive would be expected to obtain a high score on the questions relating to that attribute. Factor analysis is a statistical technique which can be used to attempt to measure the extent to which the questionnaire is measuring the stated learning concepts. The technique uses the question responses and helps to identify as well as confirm the underlying dimensions or factors within the data.

An investigation into the correlations of the responses to these questions should reveal the extent to which the questions are related. Hence the data can be analysed to determine whether the SPQ is measuring six independent variables or factors. This process of factor analysis can be considered as a technique to reduce the 42 SPQ items to six meaningful factors. An important aspect of factor analysis is that it is an interpretive rather than a predictive technique. It attempts to determine intercorrelated variables and primary constructs by identifying clusters of correlated responses to help establish characteristics within the data.

Factor analysis is generally used either as an exploratory tool to discover the structure and factors within data or as a confirmatory tool. In the latter case the variables that are thought to be related are selected and the factor analysis is used to confirm or test the original hypothesis. A fuller explanation and discussion of factor analysis and its use is provided by Child (1990), Krzanowski (1988) and Uslaner (1978a and 1978b). Factor analysis of the learning strategy and motive data collected in this research project has been carried out to confirm the structure. This is reported in the discussion of results in chapter 6.

Chapter 5:

Data Survey and Results

One must learn by doing things;
for though you think you know it
you have no certainty until you try.

Sophocles

Chapter 5 - Data Survey and Results

5.0 Introduction

The aims and objectives of the research are set out in the introduction to the thesis. In order to meet these aims and objectives it has been necessary to obtain data on a sample of engineering students. This data includes information on learning strategies and styles and on student marks for a range of assessments.

This chapter provides a description of the student sample and a summary of the results of the data survey. The results from Biggs' SPQ for the total student sample, has been obtained and is presented in section 5.2.2. The learning strategies and motives for surface, deep and achieving learning are presented. Section 5.2.3 contains the results of the learning style survey from the Honey and Mumford LSQ. Activist, reflector, theorist and pragmatist scores are provided for the student sample. Finally the distribution of marks from end of year examinations and for a range of continuous assessments is summarised at the end of the chapter. The assessed marks include:

- end of year examinations
- continuously assessed work
- design projects
- computer aided design (CAD) assignment
- aggregate marks.

5.1 Student sample

In selecting the student sample it was necessary to consider the courses offered and the level of study of students on these courses. A range of courses is delivered within the Faculty of Engineering. For administrative convenience in sampling students and in order to ensure a positive response to the survey questionnaires, degree students within the Department of Mechanical Engineering were selected. The two groups sampled were the mechanical and the integrated engineering students. These were supplemented by a small group from the MSc in Advanced Manufacturing Technology.

The degree courses within the Department of Mechanical Engineering can be studied on full-time, sandwich or part-time modes. All students on a given course, irrespective of mode, study the same material and carry out identical assessments. The sandwich mode extends over a four year period with industrial placement occurring in the third year. The full-time course is three years omitting the industrial placement, whereas the part-time mode is nominally five years. Students can transfer between modes at appropriate stages of the course and advanced standing to later years is given where students have suitable academic qualifications and/or experience.

The first year of the engineering degree courses normally introduce students to CAD and project work. This is further developed in the second year as work in these areas increases in quantity and complexity. Project work is further developed in the final year with individual and group design projects becoming more important and in which every student must satisfactorily complete an individual major study project.

In deciding on the student groups to be sampled it was necessary to ensure that representative project and CAD work was included. It was also considered desirable to sample students before they had industrial experience as one objective was to compare full-time students with more mature students having industrial experience i.e. part-time mode students. As such the second year students on the full-time and sandwich mode of the two degree courses within the department were selected. Part-time groups from years two and three of a five year course, who study corresponding material, were selected to obtain direct comparisons between mode groups.

Finally students following a MSc course were selected for inclusion in the sample for mature students. The course contains a taught element followed by a major project. The taught component is totally continuously assessed using assignments and projects. Students on the course have normally completed a first degree in a different discipline and usually bring experience and maturity to the course. Whilst the numbers on this course are too low to draw statistically significant comparisons with other groups, it is considered that they may highlight interesting points and are included to increase the sample size of the mature student group.

The courses used for the survey are listed below along with the numbers of students sampled in each group. The full-time group total includes only those students on first degree courses. The mature group includes all part-time students sampled, the MSc group and the course leader for integrated engineering.

BEng Honours Integrated Engineering		
	full-time year two	30 students
	part-time year two	11 students
	course leader	1 staff
BEng Honours Mechanical Engineering		
	full-time year two	66 students
	part-time year three	12 students
MSc Advanced Manufacturing Technology		
	full-time	5 students
	TOTAL	
	full-time	96 students
	mature students	29 students

As is the case with most engineering degrees the courses selected comprise predominately male students. The above sample is therefore significantly male oriented and contains only nine females which represents 7.2 per cent of the population sampled. With this low representation of female students no attempt has been made to compare their learning processes with those of male students.

In order to maintain anonymity a system has been devised to code the data for students sampled in the survey. This system consists of three components; a course code, mode code, course year and student number. The codes are detailed below.

Course:

- AMT - Advanced Manufacturing Technology
- IE - BEng Honours Integrated Engineering
- ME - BEng Honours Mechanical Engineering

Mode:

- F - full-time/sandwich
- P - part-time

Year:

- 2 - year two
- 3 - year three

Student number:

- 001 - first student
- 066 - student number 66

A student code of MEF2034 would represent the 34th student on the second year of the full-time (or sandwich) mode of the BEng Honours Degree Mechanical Engineering. The three digit student number at the end of the code was allocated to students in a random manner in order to maintain the confidentiality of student data. As the AMT course consists of only one year of full-time study a year code has not been included. IECL001 is the code for the course leader integrated engineering. The identity of students relative to their course code has been stored for use in future research in this area. However this information is retained in confidence and has not been published in this thesis or any other published papers on the research.

5.2 Results of survey

5.2.1 General

The results of the data survey are contained in appendix 4. Table A4.1 of this appendix contains the learning strategy data including motive and strategy scores for surface, deep and achieving learning. The structure of Biggs SPQ is such that, for each motive and strategy, the minimum and maximum scores are 7 and 35 respectively. Table A4.2 contains the preferred learning styles categorised into activist, reflector, theorist and pragmatist scores. The scores are in accordance with the Honey and Mumford LSQ having a maximum of 20 for each style. Table A4.3 contains student marks as a percentage for each of four elements of assessment and the year's aggregate mark for individual students.

The presentation of the data in the following sections summarises that presented in appendix 4. These data summaries were produced using the SPSSX statistics package.

5.2.2 Learning strategies

The following tables 5.1 to 5.3 summarise the learning motives and strategies, based on the Biggs study process questionnaire, for the total student sample utilising the data held within appendix 4. Detailed discussion of this data and comparison with previous research studies is contained in chapter 6. The following presents the information with a minimum of comment on the significance of the results. The information is considered to be too important to relegate to appendices and has therefore been included here. Based on a sample size of 125 students an analysis of the learning strategy scores and their variance indicates that the mean scores are correct to within 1 mark at a statistical confidence level of 95 per cent.

Table 5.1 presents the grouped data for the surface motives and strategies of the 125 students. The data includes frequencies and cumulative frequencies. The means and standard deviations for the respective surface motive and surface strategy is summarised at the bottom of the table.

Table 5.1 - Surface learning distribution

	Surface Motive		Surface Strategy	
Score	frequency	cumulative	frequency	cumulative
7-10	1	1	1	1
11-14	6	7	11	12
15-18	28	35	20	32
19-22	26	61	42	74
23-26	23	84	27	101
27-30	31	115	23	124
31-34	10	125	1	125
35	0	125	0	125
mean	22.7		21.4	
S.D.	5.5		4.9	

Based on the norms published by Biggs (1987b), see chapter 4, 39 (31%) of the student sample have a low surface motive, 36 (29%) an average and 50 (40%) have an above average surface motive. The corresponding figures for the surface strategy are 32 (25%), 56 (45%) and 37 (30%). It would appear therefore that although there is a relatively high percentage of students with a surface motive this is not matched by the strategy that they adopt. The mean scores of 22.7 and 21.4 for the motive and strategy respectively both fall within the average range for the norms.

Table 5.2 below presents deep motive and strategy data in the same format as the above surface learning data.

Table 5.2 - Deep learning distribution

	Deep Motive		Deep Strategy	
Score	frequency	cumulative	frequency	cumulative
7-10	0	0	0	0
11-14	18	18	5	5
15-18	17	35	25	30
19-22	52	87	48	78
23-26	26	113	34	112
27-30	12	125	12	124
31-34	0	125	1	125
35	0	125	0	125
mean	20.4		21.4	
S.D.	4.3		4.0	

Again comparison of these scores with Biggs' norms gives an indication of the level of deep learning adopted by the students. 49 (39%) have a below average deep motive, 53 (42%) an average and 23 (19%) an above average deep motive. The corresponding strategy results are 38 (30%) for below average, 60 (48%) average and 27 (22%) above average. There seems to be some agreement between deep motives and strategies, however these do not necessarily give an indication of the correlation. This is discussed in more detail in chapter 6. The mean scores of 20.4 and 21.4 for the motive and strategy respectively both fall within the average range for the norms.

The final table on learning motives and strategies is presented below. Table 5.3 includes data on achieving learning in the same format as the above.

Table 5.3 - Achieving learning distribution

	Achieving Motive		Achieving Strategy	
Score	frequency	cumulative	frequency	cumulative
7-10	0	0	2	2
11-14	7	7	11	13
15-18	19	26	29	42
19-22	43	69	38	80
23-26	35	104	30	110
27-30	18	122	13	123
31-34	3	125	2	125
35	0	125	0	125
mean	21.8		20.5	
S.D.	4.5		5.0	

The final comparison of these scores with Biggs' norms gives an indication of the level of achieving learning. The scores are 21 (17%) for a below average motive, 48 (38%) for an average and 56 (45%) for an above average achieving motive. The corresponding strategy results are 35 (28%) for below average, 55 (44%) average and 35 (28%) above average. There does not seem to be such a strong agreement between achieving motives and strategies. However, their correlations are discussed in detail in chapter 6. The mean scores of 21.8 and 20.5 for the motive and strategy respectively both fall within the average range for the norms.

5.2.3 Learning styles

The following tables 5.4 and 5.5 summarise the learning styles, based on the Honey and Mumford (1986a) learning styles questionnaire, for the total 125 students sampled and is based on data held within appendix 4. Grouped data on frequencies and cumulative frequencies is presented for each of the four styles. The mean and standard deviation of the respective learning style for the 125 students is included at the end of the tables. Based on a sample size of 125 students an analysis of the learning style scores and their variance indicates that the mean scores are correct to within 1 mark at a statistical confidence level of 95 per cent.

Detailed discussion of this data and comparison with previous research studies is contained in chapter 6. The following presents the information with a minimum of comment on the significance of the results.

Activist and reflector style scores are presented together in table 5.4 below.

Table 5.4 - Activist and reflector distributions

	Activist		Reflector	
Score	frequency	cumulative	frequency	cumulative
0	1	1	0	0
2	1	2	1	1
4	6	8	2	3
6	14	22	0	3
8	28	50	3	6
10	24	74	11	17
12	22	96	26	43
14	16	112	23	66
16	9	121	28	94
18	4	125	17	111
20	0	125	14	125
mean	10.2		14.5	
S.D.	3.6		3.6	

Inspection of the above table, relative to the norm scores published by Honey and Mumford (1986a), see chapter 4, shows that some 41 per cent of the student sample have a strong or very strong activist preference to learning and some 47 per cent have a strong or very strong preference towards the reflector style of learning. The following table lists theorist and pragmatist style scores. Again using the published norms 41 per cent have a strong or very strong theorist style and 26 per cent a strong or very strong pragmatist style preference. It should be noted that students can have preferences towards two or more styles and it is not anticipated that the above will total 100 per cent. One of the aims of higher education is to develop the all round learning skills of students and it is therefore expected that the students will have preferences in a number styles.

The theorist and pragmatist learning style grouped data is presented in table 5.5 below.

Table 5.5 - Theorist and pragmatist distributions

	Theorist		Pragmatist	
Score	frequency	cumulative	frequency	cumulative
0	0	0	0	0
2	1	1	1	1
4	4	5	3	4
6	5	10	6	10
8	16	26	12	22
10	22	48	22	44
12	26	74	21	65
14	27	101	28	93
16	16	117	22	115
18	2	119	9	124
20	6	125	1	125
mean	12.0		12.3	
S.D.	3.7		3.6	

5.2.4 Student marks

The following tables show the distribution of marks for various elements of the courses. The marks are grouped into bands of 10 per cent and are categorised into five components. These components represent the wide range of activities that are assessed within engineering degree courses. The analysis of these assessments will facilitate a comparison of the strengths and weaknesses with the strategies/styles of engineering students when carrying out different learning activities.

Examinations on degree courses within the Faculty of Engineering of the Polytechnic are the conventional unseen type, typically asking for five out of eight questions to be answered. They are normally held at the end of the academic year, however some may be held part way through the year. The examination scores shown below are the marks for all of the students sampled. The MSc student group does not undertake formal examinations. For comparison purposes and in order to ensure compatibility of marks within all groups and categories an estimate of examination marks for the five students within this group has been made. This estimate is based on the aggregate marks compared to other part-time students in the sample.

Continuous assessment is becoming more widely used within higher engineering education for reasons discussed in the literature review of chapter 2. This type of assessment, along with the use of projects, is an increasingly important approach in engineering education and both have therefore been highlighted for inclusion in the research into correlations between learning strategies/styles and assessment. Computer Aided Design (CAD) marks have also been included. All students in the sample completed a CAD assignment after following a study course that, by the character of the subject, was experiential in nature. Students are provided with basic instruction on the use of the CAD system, they are then directed to use self learning files held within the system and carry out staged engineering drawings before completing an assignment based on an engineering application.

The first table shows the distribution of marks for the total sample of students. The mean and standard deviation of the marks for each category are included at the end of the table. Based on the size of the student sample used and the variance as measured by the standard deviations the maximum error in the mean marks is no greater than two marks at a confidence level of 95 per cent.

The data is presented in group bands of 10 per cent and correspond with the bands used for classifying students at the end of the final year. Table 5.6 includes the total student sample. Tables 5.7 and 5.8 present the same data for the full-time and the part-time student groups respectively.

The aggregate marks in the final column are computed from contributions of individual marks from the various subjects. Each subject is assessed either fully by examination, or fully by continuous assessment or by a combination of both. The project and CAD marks normally contribute towards a subject, such as integrated design studies, that is continuously assessed. Although it might be argued that these elements are already being considered within the continuous assessment, they provide only a partial contribution and are considered sufficiently important to be included in their own right for the research into correlations with learning techniques.

Table 5.6 - Distribution of student marks

Mark Per cent	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
< 30	2	2	1	1	1
30 - 39	19	2	2	2	0
40 - 49	43	2	10	7	33
50 - 59	33	26	20	18	50
60 - 69	18	57	60	54	31
70 - 79	8	34	30	32	9
> 79	1	1	1	10	0
mean	51.1	64.1	62.8	64.8	55.6
S.D.	11.4	10.1	10.6	11.4	9.3

Honours degree courses at the Polytechnic utilise the following range of marks to classify students into grades:

first class	>=70
upper 2nd class	60 - 69
lower 2nd class	50 - 59
third class	40 - 49
pass	35 - 39
fail	< 35.

Based on these grading categories, if students perform similarly in their final year of study then it might be expected that the distribution of grades would be 7% first class, 25% upper second, 40%

lower second (the grade for an average student), and 27% third class with 1% failing. The 1% failure represents just one student failing which is a small value subject to large random errors. It is hoped that students do not fail in their final year. Weaker students who are unlikely to succeed at a course of study should preferably be identified in the very early stages of a course and be directed to appropriate levels of study, rather than to proceed to the final year with little prospect of success.

The mean aggregate mark of 55.6% is slightly above the mid-point of the lower second class. The standard deviation is 9.3%. Subtracting and adding 1.5 standard deviations to the mean mark gives values of 41.6% and 69.6%. These values are sufficiently close to the grade bands such that a spread of three standard deviations will range from the pass band to a first class award. The above data and analysis indicates that the marks are typical of results expected from a set of second year degree students.

The mean marks for the three non-examined elements of the courses are 64.1%, 62.8% and 64.8% for continuous assessment, project work and CAD respectively. These mean marks are all higher than the examination mean mark of 51.1%. Analysis of these means using standard t-tests shows that the marks are statistically higher than the examination marks at the 99% level of confidence. This level of confidence is highly significant indicating that students following courses of study that have a high content of continuous assessment have a greater chance of success than those who follow more traditional courses with a higher proportion of examinations. This highlights issues to be addressed by course planning teams where it is proposed to move away from formal examination methods to continuous assessment. Whilst the move away from assessments that might unduly reward rote learning and memory is to be commended, care must be taken in assessing students using continuous assessment. Assessment based on grades rather than absolute percentage values might be one way of overcoming this problem. The move towards continuous assessment could explain the improvement in GCSE grades at schools during recent years. It is hoped that this change in assessment method is part of an instrument to encourage independent learning skills rather than as a means of ensuring more students progress to GCE 'A' levels and then on to higher education.

Anecdotal evidence suggests that older and hence more mature part-time students show greater commitment and motivation in their studies and as such achieve higher marks than their full-time counterparts. A comparison of full and part-time student marks has been included in the two following tables in order to test this hypothesis.

Table 5.7 - Distribution of full-time student marks

Mark Per cent	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
< 30	1	2	1	1	1
30 - 39	17	1	0	2	0
40 - 49	37	1	10	4	29
50 - 59	24	25	18	17	41
60 - 69	12	50	48	52	20
70 - 79	4	17	19	13	5
> 79	1	0	0	7	0
mean	50.1	62.6	61.7	63.0	54.3
S.D.	11.4	9.6	10.0	10.9	9.1

Table 5.8 - Distribution of part-time student marks

Mark Per cent	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
< 30	1	0	0	0	0
30 - 39	2	1	2	0	0
40 - 49	6	1	0	3	4
50 - 59	9	1	2	1	9
60 - 69	6	7	12	2	11
70 - 79	4	17	11	19	4
> 79	0	1	1	3	0
mean	54.7	69.1	66.8	71.1	60.0
S.D.	11.0	10.6	11.7	11.1	8.8

A comparison of the mean marks shows that for all five elements of the above marks, the part-time student groups perform better than full-time student groups. Based on the null hypothesis that part-time student marks are no higher than full-time groups, standard statistical t-tests have been carried out on the data. This shows that the difference in marks is statistically significant at a confidence level of 99% for all elements except for the examination marks which has a 95% confidence level. The spread of marks in each group is very similar as evidenced by the standard deviations. F-tests show that there is no statistically significant difference between the standard deviations of the marks for the two student groups. Based on this student sample there is highly significant statistical evidence that part-time student groups perform better than full-time student groups.

A fuller analysis of the above marks related to the learning strategies and styles of students is contained in the next chapter.

Chapter 6:
Discussion of Results

I keep six honest serving men
(they taught me all I know):
Their names are What and Why and
When and How and Where and Who.
Rudyard Kipling

Chapter 6 - Discussion of Results

6.0 General

This chapter presents the results of the investigation into student learning strategies and styles along with student performance on a variety of assessments. Correlations between the above have been carried out and are discussed. The chapter first compares the learning strategy data with that collected by Biggs (1987b), then presents the results of a factor analysis of this learning strategy data and correlates the motives and strategies for surface, deep and achieving learning. The next section focuses on the learning styles of students by comparing the data with norms produced from information collected by Honey and Mumford (1986a). The final sections of this chapter present the investigations into correlations with both learning strategies and styles, and the data on assessment performance. Where appropriate comparisons are made between full-time and part-time students.

6.1 Learning strategies

Figures 6.1 to 6.3 inclusive present the distribution of learning motives and strategies for surface, deep and achieving learning respectively. The data presented represents the total sample of students and provides a comparison with data collected by Biggs (1987b). The Biggs' data involves various categories of Australian student groups including:

- University arts
- University education
- University science
- CAE arts
- CAE education
- CAE science.

Each of the above are further sub-divided into male and female groups. The sample of Australian College of Advanced Education (CAE) male science students were selected for comparison with the Polytechnic engineering students. This sample includes 228 students and is considered to be the most suitable group to be used in the comparison with the sample of engineering Polytechnic students who were selected for the research.

6.1.1 Comparison with Biggs' data

Surface learning

Figure 6.1 presents the distribution of surface motives and strategies for the Polytechnic sample of engineering students and for the Biggs' sample of CAE science students. The comparisons presented indicate that surface learning scores for each group are very similar. Overall the surface motives of the Polytechnic sample is slightly higher than those of the Biggs' group.

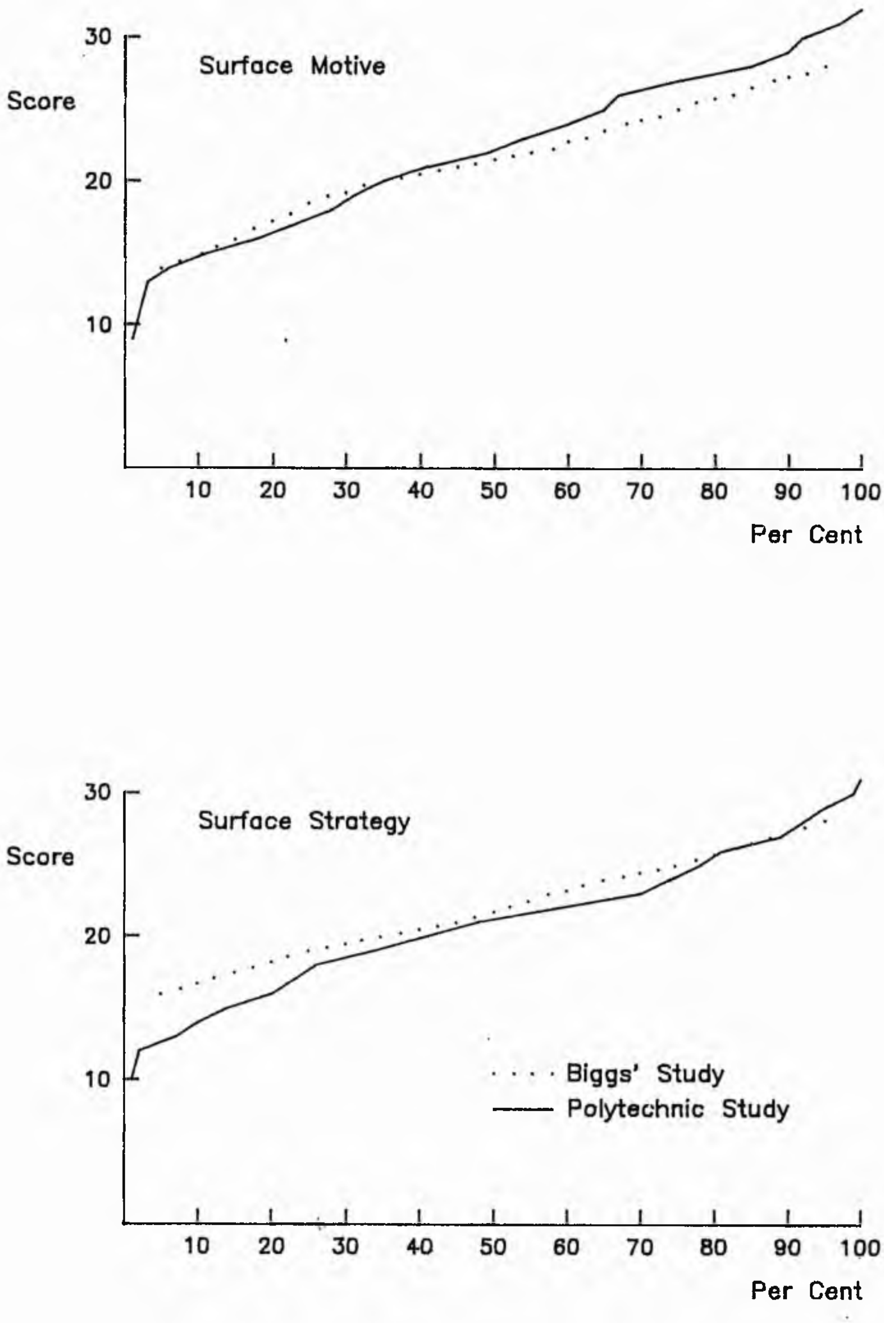


Figure 6.1 - Surface learning

In particular more of the Polytechnic students achieved high surface motive scores. However the data indicates that slightly less of this group adopt a surface strategy in their learning. Overall the information presented in figure 6.1 indicates that the Polytechnic sample of students adopts a similar surface approach to the Biggs' sample.

Table 6.1 below provides further information regarding surface learning techniques; the mean and standard deviation for each type is included. The table also indicates the percentage of students who have above average, average and below average scores in the respective categories of surface learning. Above average surface learning is indicated by a '+' sign, below average by a '-' sign and average responses are indicated by a 'O'. This convention has been adopted throughout this chapter.

Table 6.1 - Surface learning

	Surface Motive					Surface Strategy					Surface Approach				
	-	O	+	mean	SD	-	O	+	mean	SD	-	O	+	mean	SD
	per cent					per cent					per cent				
Polytechnic	31	29	40	22.7	5.5	25	45	30	21.4	4.9	28	36	36	44.0	9.8
Biggs' group	20	50	30	22.5	4.8	20	40	40	22.2	4.5	20	50	30	44.7	7.3

It is perhaps surprising within higher education that a relatively large group (40 per cent) of the students surveyed reveal a surface motive for learning. This is not matched by the strategy scores in which 30 per cent are identified as using a surface strategy. Overall just over 1/3 of students adopt a surface approach to learning. Whilst it is reassuring that the majority do not use surface methods, it is of concern that there are so many surface learners. Engineering honours degree courses within the Polytechnic tend to have a high level of class contact with associated heavy student workloads. It would be interesting to investigate the effects of workload on student learning strategies. It is possible that a heavy workload gives the students the perception that it is necessary to concentrate efforts on meeting the next deadline rather than taking the time to study a topic in depth. This could have the effect of constraining students to surface techniques in their study habits. A comparison of the means and standard deviations shows that there is little significant difference between the surface learning approaches of the Polytechnic sample and Biggs' sample of students.

Deep learning

Figure 6.2 presents a comparison of deep learning for the two groups.

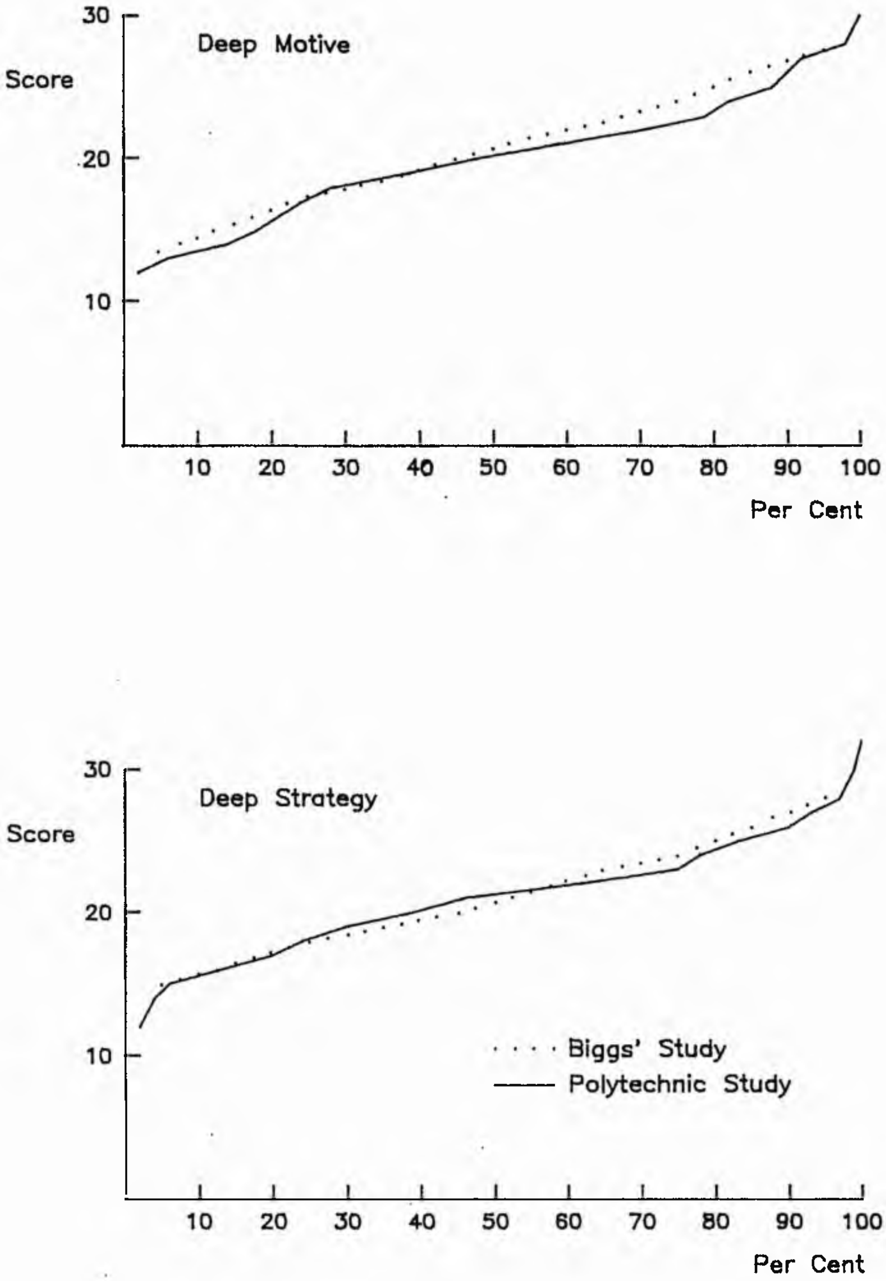


Figure 6.2 - Deep learning

As is shown the Polytechnic students generally exhibit lower scores for the deep learning motives than the Biggs' student sample. However this is only marginally reflected in the deep strategy data, there being little difference exhibited between the groups in their strategy scores. Further data on deep learning for the two groups is provided in table 6.2 below.

Table 6.2 - Deep learning

	Deep Motive					Deep Strategy					Deep Approach				
	-	O	+	mean	SD	-	O	+	mean	SD	-	O	+	mean	SD
	per cent					per cent					per cent				
Polytechnic	39	42	19	20.4	4.3	30	48	22	21.4	4.0	51	29	20	41.8	7.7
Biggs' group	35	40	25	21.1	5.0	30	40	30	21.9	4.6	40	35	25	43.0	8.6

There is a relatively low level of deep learners within the student group. Approximately 20 per cent of the Polytechnic student group have a deep motive, deep strategy and an overall deep approach to learning. It is interesting that this level of students with a deep approach is similar to the numbers of students having low scores in the surface approach. It might be expected that deep learners will have a high score in this area and a low surface learning score. This inverse correlation is discussed further later. A comparison with the Biggs student group shows that there is little significant difference between the group means and standard deviations for deep learning.

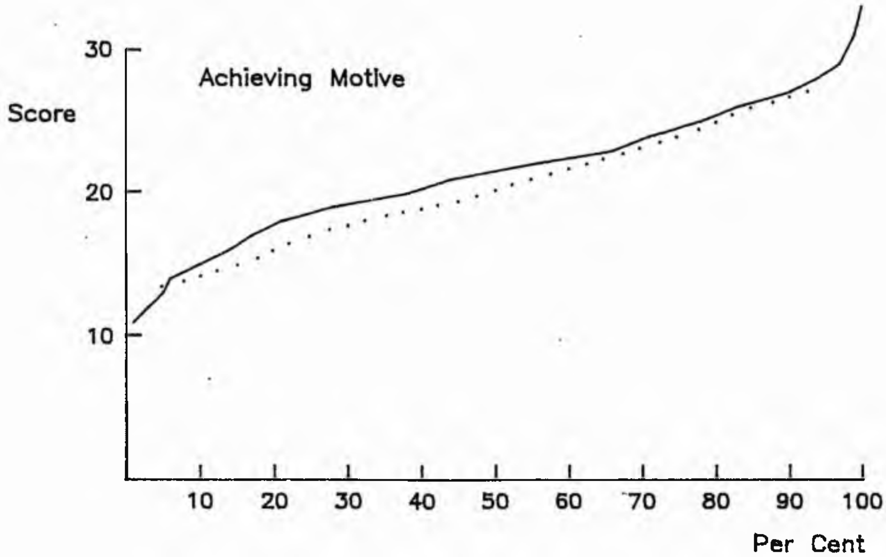
Achieving learning

Figure 6.3 presents the data for achieving learning. The figure shows that there is little difference between the Biggs and Polytechnic student groups. This is confirmed by the means in table 6.3 below.

Table 6.3 - Achieving learning

	Achieving Motive					Achieving Strategy					Achieving Approach				
	-	O	+	mean	SD	-	O	+	mean	SD	-	O	+	mean	SD
	per cent					per cent					per cent				
Polytechnic	17	38	45	21.8	4.5	28	44	28	20.5	5.0	21	36	43	42.3	7.7
Biggs' group	35	30	35	19.9	5.4	35	45	20	19.6	5.2	40	30	30	39.5	9.0

It is encouraging that there is a high level of achieving learners within the Polytechnic group sampled with some 43 per cent adopting an overall achieving approach, and only 21 per cent with low achieving approach scores. Table 6.3 and figure 6.3 both indicate that the Polytechnic students have slightly higher scores for achieving learning.



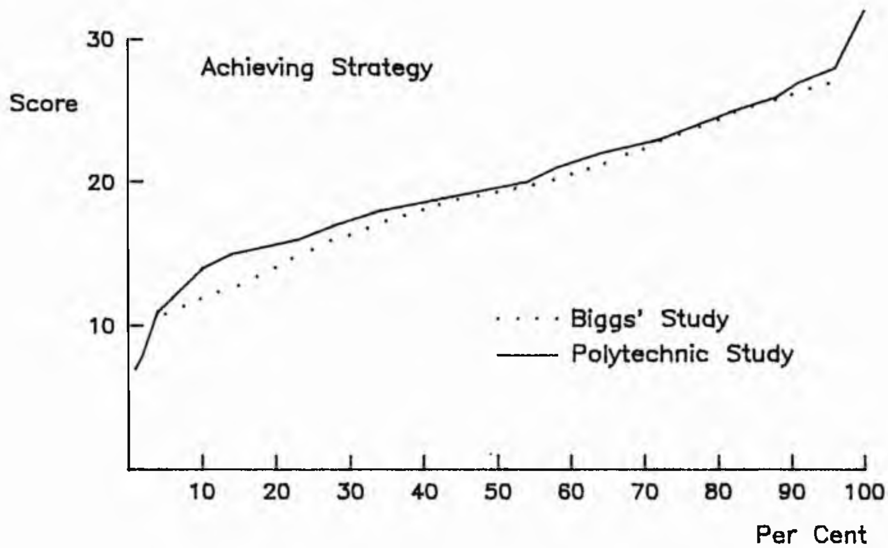


Figure 6.3 - Achieving learning

Overall the above analysis shows that there are no major differences in the three learning motives, strategies, and approaches between the sample of Nottingham Polytechnic students and the Australian science students sampled by Biggs. The only category that indicates a significant difference is the deep approach in which the Polytechnic students displayed lower deep motive scores. In all of the other motive and strategy categories the scores for the two groups are very similar. This gives a strong indication that for Nottingham Polytechnic and Australian CAE engineering and science students there is no significant differences between learning motives and strategies.

6.1.2 Full-time and part-time differences

Generally part-time degree students are mature being 21 years of age or older. Most start the part-time engineering degree courses at Nottingham having successfully completed B/TEC Higher National Certificate or Diploma programmes and are now studying to meet a specific career related goal. Anecdotal evidence suggests that this goal is allied to career progression through the achievement of Chartered Engineer status. As such it is suggested that they tend to be single minded in their study and see the course as a means to an end rather than as an opportunity to broaden their education. Part-time degree students are thought to be highly motivated and committed in their studies. Certainly, as a group, their assessed marks are higher than those of full-time students (see section 5.2.4).

The following table presents a comparison between the learning strategies and motives of part-time and full-time students. The two groups are sub-sets of the sample of Nottingham Polytechnic engineering students. There are 96 full-time and 29 part-time students in the two respective groups.

The left half of the table provides data for full-time students and the right half for part-time students. The table presents data in two forms for each student group. The first of the three numbers for each of the two modes of study gives the number of students that obtained a higher than average score in the appropriate motive, strategy or approach score. For example there were 41 of the 96 full-time students who had a higher than average surface motive, and 9 of the 29 part-time sample who also were higher than average in this category. The next two numbers in each group supply the mean score with the standard deviation for each learning type.

Table 6.4 - Full-time and part-time learning strategies

	Full-time students			Part-time students		
	number > ave.	mean score	SD	number > ave.	mean score	SD
Surface motive	41	22.9	5.5	9	21.8	5.5
Surface strategy	32	21.7	4.9	5	20.4	4.8
Surface approach	36	44.6	9.8	8	42.2	9.8
Deep motive	14	20.1	4.2	9	21.4	4.6
Deep strategy	18	21.0	4.0	9	22.5	3.7
Deep approach	16	41.1	7.6	9	43.9	7.8
Achieving motive	42	21.8	4.3	14	21.9	5.2
Achieving strategy	23	20.2	4.7	12	21.4	5.6
Achieving approach	38	42.0	7.3	16	43.2	9.2

Surface learning

Comparison of the above means for surface learning indicates that the full-time students consistently obtained higher scores for their motives and strategies, with little difference in the standard deviations. A statistical analysis of this surface learning data has been carried out using standard t-tests to compare means. In carrying out the statistical analysis the test performed was to determine whether the part-time student group has lower surface learning scores compared to the full-time student group. The t-test is therefore a one-tailed test. The analysis was based on the null hypothesis that the part-time student mean surface scores are not different to the full-time student scores. The alternative hypothesis is that less part-time students adopt surface techniques, i.e. their mean surface scores are lower than the full-time mean surface scores.

In the event the results showed that the probability that this null hypothesis is true was 0.17 for the surface motive, 0.11 for the strategy and 0.13 for the overall surface approach. From this the balance of probability is that the surface learning scores of the full-time students are higher than those of the part-time group. However, whilst this evidence indicates that full-time students have a greater tendency to adopt surface techniques in their learning habits the data is not sufficiently strong to reject the null hypothesis using a statistical confidence level of 90 per cent or more. The hypothesis could only be rejected with 83 per cent confidence for the surface motive and 89 per cent and 87 per cent confidence for the strategy and approach scores respectively.

The data in table 6.4 concerning the number of students having higher than average surface scores shows that 43 per cent of the full-time students have a surface motive compared to 31 per cent of the part-time students. The comparative figures for surface strategy are 33 per cent for the full-time group and 17 per cent for the part-time group. The overall surface approach figures are 37 per cent and 28 per cent for the full and part-time groups respectively. There is therefore a greater proportion of full-time students adopting surface learning techniques than part-time students. This supports the above inferences drawn from the data on means and standard deviations.

Deep learning

As might be expected the information in table 6.4 on deep learning shows the opposite trend to surface learning. The part-time student mean scores are higher than the full-time student group marks in all three deep categories, i.e. motive, strategy and overall approach. There is little difference in the standard deviations indicating a similar spread of scores about the respective means. The statistical analysis of the deep learning data has also been carried out using standard t-tests to compare means. Again the analysis was based on the null hypothesis that the part-time mean deep scores are no different to the full-time scores. However, this time the alternative hypothesis was based on the part-time student mean scores being greater than the full-time student mean scores. The results of this statistical analysis showed that the probability of the null hypothesis being true was 0.09 for the deep motive, 0.04 for the strategy and 0.05 for the overall deep approach. This evidence is such that the null hypothesis can be rejected and shows that part-time students have a greater tendency to adopt deep learning. The hypothesis that the part-time group's deep learning scores are greater than the scores for the full-time group scores is statistically significant. With regard to deep motives the hypothesis is statistically significant at a confidence level of at least 90 per cent. The corresponding confidence levels for deep strategies and approaches is 96 per cent and 95 per cent respectively. These levels of confidence indicate that the difference in deep motive means is statistically significant, and that the differences for the deep strategy and deep approach are both very significant.

The data in table 6.4 concerning the number of students having higher than average deep scores shows that only 15 per cent of the full-time students have a deep motive compared to the 31 per cent of part-time students. The comparative figures for deep strategy are 19 per cent for the full-time group and 31 per cent for the part-time group. The overall deep approach figures show 17 per cent and 31 per cent for the full and part-time groups respectively. There is therefore a greater proportion of part-time students adopting deep learning techniques than full-time students. This again supports the above inferences drawn from the data on means and standard deviations and clearly shows that the part-time student group obtained a higher level of deep learning based on the Biggs SPQ. The levels of confidence show that the results are significant for the deep motive and very significant for both strategy and approach.

Achieving learning

The final part of table 6.4 concerns achieving learning. This time the part-time mean scores are higher than the full-time marks in all three categories, i.e. motive, strategy and overall approach. However the means for achieving motive are only marginally higher. Again there is little difference in the standard deviations indicating a similar spread of scores about the respective means. The statistical analysis of the achieving learning data has also been carried out using standard t-tests to compare means. The same null hypothesis was used, furthermore the alternative hypothesis adopted was the same as for deep learning, which is based on the part-time mean scores being greater than the full-time student mean scores. The results of this statistical analysis showed that the probability of this null hypothesis being true was 0.49 for the achieving motive, 0.16 for the strategy and 0.26 for the overall achieving approach. Based on these probabilities there is no statistically significant evidence to suggest that there is a difference in the achieving motives of part-time students compared to full-time students. Whilst the evidence indicates that part-time students have a greater tendency to adopt an overall achieving approach, and in particular an achieving strategy the evidence is not sufficiently strong to reject the null hypothesis using a statistical confidence level of 90 per cent or more. The hypothesis could only be rejected with 84 per cent confidence for the achieving strategy and 74 per cent confidence for the approach scores.

The data in table 6.4 shows that the proportion of students having higher than average achieving motive scores is 44 per cent for the full-time students compared to 48 per cent for part-time students. The comparative figures for achieving strategy are 24 per cent for the full-time group and 41 per cent for the part-time group. The overall achieving approach figures show 40 per cent and 55 per cent for the full and part-time groups respectively. The data is inconclusive with regard to achieving motives. However the proportion of part-time students having a higher than average achieving strategy and achieving approach is greater than the full-time student group. This tends to support the above inferences drawn from the data on means and standard deviations.

Assessment marks

The means and standard deviations of the assessment marks, reproduced from section 5.2.4, for both of the groups of students is summarised in table 6.5 below. The first set of data gives the full-time students' percentage marks for each of five different assessment types. The part-time students' marks are provided in the right hand side of the table to give a direct comparison.

Table 6.5 - Comparison of full-time and part-time student marks

	Full-time group mark - per cent		part-time group mark - per cent	
	mean	SD	mean	SD
Examination	50.1	11.4	54.7	11.0
Continuous Assessment	62.6	9.6	69.1	10.6
Design Project	61.7	10.0	66.8	11.7
CAD	63.0	10.9	71.1	11.1
Aggregate	54.3	9.1	60.0	8.8

As can be seen the mean part-time marks are all consistently higher than the set of marks for the full-time student group. The standard deviations are all similar for both student groups indicating a similar spread of marks about the respective means. A statistical analysis of this data was carried out based on the null hypothesis that there are no differences in the means. The alternative hypothesis being that part-time students achieve higher mean marks. As stated in section 5.2.4 this analysis shows that the part-time marks are higher than the full-time student marks at a statistical confidence level of 99 per cent for all assessment types except the examination marks. The level of significance for the examination marks is 95 per cent which is still statistically significant.

The above information is presented graphically as horizontal bar charts in figure 6.4 below.

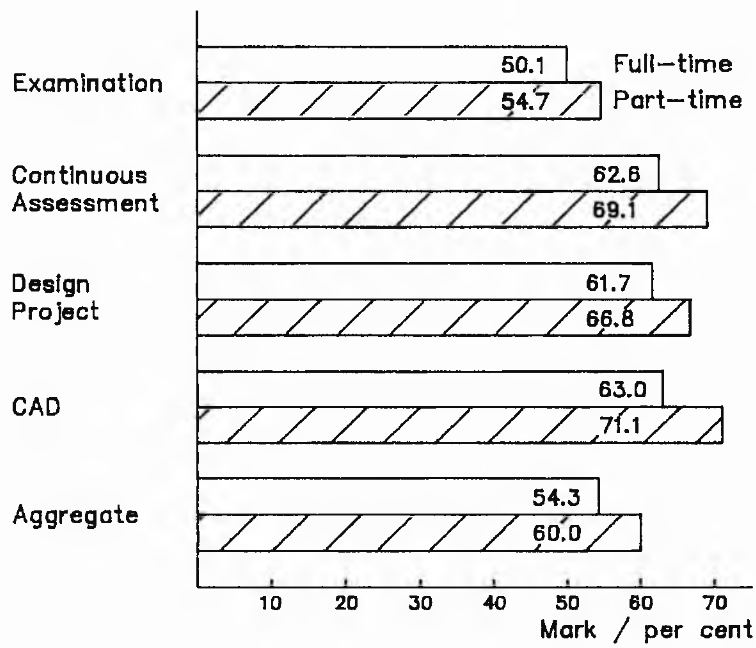


Figure 6.4 - Comparison of full-time and part-time student marks

This figure clearly illustrates that the part-time student group achieved higher marks in all aspects of assessment including work that is continuously assessed as well as formally examined. Based on the distribution of marks, and assuming that the final year distribution will be similar, an estimate of the distribution of honours grades has been carried out. This distribution is shown in table 6.6.

Table 6.6 - Estimated final honours grades distribution

	Full-time group		part-time group	
	number	per cent	number	per cent
First class	5	5	4	14
Second class division 1	20	21	11	39
Second class division 2	41	43	9	32
Third class	29	30	4	15
Pass	0	0	0	0
Fail	1	1	0	0

It needs to be emphasised that these are only estimates of final grades. In effect there may well be a change in the distribution of marks. In particular the majority of full-time engineering students at the Polytechnic spend their third year in industry. It is possible that this industrial experience allied to the increased motivation of the final year may have a significant effect on the full-time group and increase their grades on graduation. It will be interesting to compare these estimates with the actual final grades at the end of the 1992-3 academic session. The distribution of grades shows that the part-time student group has the potential to obtain better grades than the full-time students. The estimate is that 53 per cent of the part-time group might obtain a first or upper second class honours degree compared to 26 per cent of the full-time students.

The above indicates that the higher marks, and hence potentially better grades, for the part-time students are statistically significant. This can be explained to a certain extent by the higher motivation and hence learning strategies that are adopted by this type of student. This is evidenced by the higher deep and achieving learning scores and the lower surface learning scores obtained by the part-time students as reported above.

However other influences may contribute to these differences. Part-time students have industrial experience and are in a better position to directly relate their studies to the practical industrial situation. This experience is of direct benefit when carrying out design and other project work including Computer Aided Design (CAD). Furthermore they often have access to physical and human resources that are not available to full-time students. This again is often useful in project work. The human resource referred to involves help from colleagues in problem solving and often comprises of personal one to one tutorial support.

It might appear from this that part-time students have a major advantage over full-time students. In reality the pressures of work and family commitments cause greater problems to the part-time student. The direct class contact time is also lower being typically 2/3 of the time that is available to full-time students. However, both student groups carry out identical assessments. It is generally accepted, by both academic staff and students, that the part-time route involves more effort and commitment than the corresponding full-time route. The performance of part-time students can therefore be partially explained by their higher learning motives and strategies as measured by the Biggs SPQ.

6.1.3 Factor analysis

An outline of the statistical technique known as factor analysis is contained in chapter 4. This analysis has been carried out on the data using the SPSSX statistics computer package. The primary aim of applying factor analysis was to confirm the common factors of the 42 items in Biggs' SPQ. The first step used Principal-Components analysis to determine the communalities and the eigenvalues which in turn established the number of factors that are required to define the structure of the data. With a single strategy and motive for each of the three learning types (surface, deep and achieving), it is anticipated that at least six factors will emerge from this primary analysis. Having determined the relevant factors the correlations of the responses, of the 42 questions in the SPQ, against each of the factors is obtained. These correlations are known as the factor loadings. Loadings that are significant for a given factor are grouped together to determine the set of questions that contribute towards a given strategy or motive.

Sample size

There is considerable debate as to the minimum sample size to be used in factor analysis such that a reliable analysis is obtained. The suggested sample size ranges from a sample of 1 for each variable (Nunnally, 1978), to a level of 10 for every variable (Aleamoni, 1976). The above are based on *guestimation* from the extreme of only one subject for each variable to the other extreme in which researchers are playing very safe. This higher limit involves large resources in obtaining and analysing test results. Based on the two criteria above the sample size required for the 42 items of Biggs' SPQ would range from 42 to 420 students. Baggeley (1982) gives a useful suggestion based on the number of variables and an approximation of the average correlation between all variables. For this research project the average correlation from the factor analysis of six major factors was found to be approximately 0.24. The number of variables is 42. Using Baggeley's criterion the minimum required ratio of subjects to the number of variables is 2.7. The minimum sample size is therefore 2.7 x 42 i.e. 113 students. The sample used, of 125 students, is therefore greater than the minimum required for reliable factor analysis of the data on Baggeley's criterion.

Number of factors

As stated earlier the first step is to determine the number of factors that need to extracted from the data. The factor analysis process will extract a large number of factors, only some of which will be significant common factors. There are several methods available for extracting the common factors. The first of the two most popular simply relies on the criterion of the latent root or eigenvalue of the factor being greater than one. This latent root or eigenvalue is the sum of the square of the loadings under a given factor. It is therefore a measure of the variance i.e. similar to the square of a correlation coefficient. Using this method some eleven common factors can be extracted.

As the factors increase then the amount of variance in the data that is not common increases. This is known as unique variance and does not contribute towards the grouping of data into factors. The proportion of this unique variance in later factors becomes so great that it swamps the common variance. The second method, recommended by

Cattell (1978), uses the scree test, which is a means of identifying the optimum number of factors that can be taken out before this intrusion of unique variance swamps the common variance. For this method the latent roots or eigenvalues of the factors are plotted against the factor number to produce what is known as a scatter plot. Figure 6.5 shows the scatter plot of eigenvalues produced from the factor analysis of the student responses to the 42 questions. At the higher eigenvalues the graph is curved. Whereas at the other extreme the plot straightens to approximate a linear relationship. The linear part of the graph is known as the scree. The geological analogy being that of rocks which collect at the bottom of a rocky slope, i.e. the scree. The kink at factor number nine is typical of scatter plots and helps to indicate the start of the scree. Using the scree test ten common factors can be extracted.

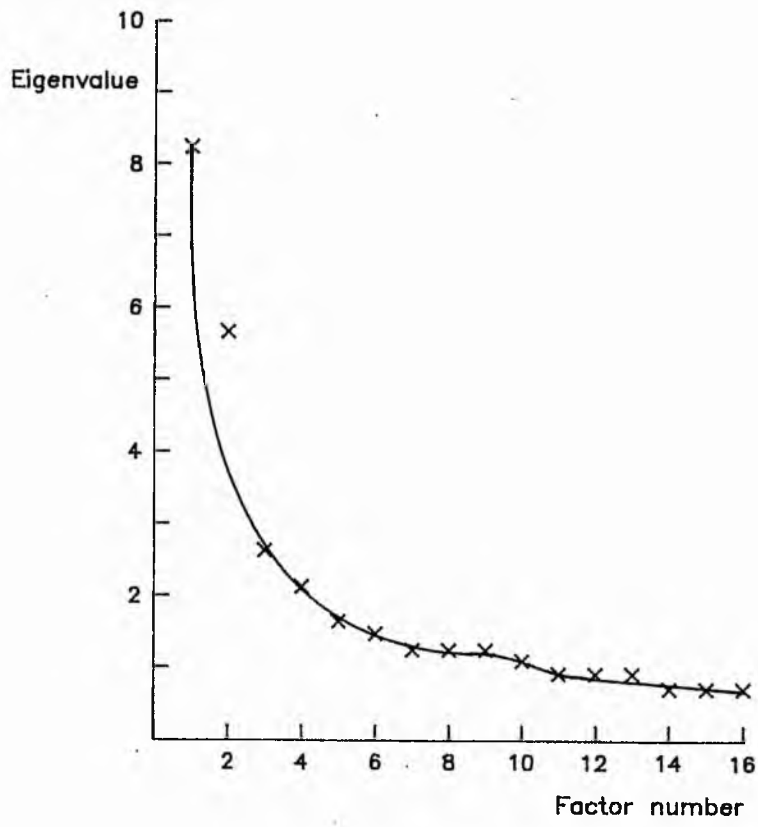


Figure 6.5 - Factor analysis scatter plot

For the arguments given above the first ten factors were extracted for further analysis. The value of the eigenvalue of each factor gives an indication of the amount that the factor contributes to the total variance. The maximum loading for a given item is 1.0. The maximum value of the eigenvalue for a particular factor is therefore 42 being the sum of the square of the maximum loading for each of the 42 items. The first factor, having an eigenvalue of 8.24, contributes 8.24/42 i.e 20 per cent of the total variance. The eigenvalues of the first ten extracted factors are listed below.

Table 6.7 - Factor eigenvalues

Factor	Eigenvalue	Variance per cent	Factor	Eigenvalue	Variance per cent
1	8.24	19.6	6	1.48	3.5
2	5.67	13.5	7	1.32	3.1
3	2.63	6.3	8	1.28	3.0
4	2.13	5.1	9	1.25	3.0
5	1.65	3.9	10	1.10	2.6

The table shows the eigenvalues and the percentage contribution that each factor makes towards the total variance. The first six factors contribute a total of 52 per cent whereas the contribution of all ten factors is just 64 per cent, i.e. the last four factors only provide a 12 per cent contribution to the total variance.

A factor analysis has been carried out with the number of factors limited to ten. In carrying out the analysis an orthogonal rotation of the data using the Varimax technique was utilised as well as an oblique rotation using the Oblimin method. These two rotations help to simplify the structure of the analysis and are useful in classifying data clusters from the factor loadings. A clear and concise explanation of these two techniques is provided by Child (1990).

Significant factor loadings

The factor analysis output provided by the SPSSX software consists of loadings (correlations) of each of the 42 items against each of the ten factors. The magnitude of these loadings range from 0.002 to 0.817. When carrying out factor analysis it is conventional to report those loadings that are significant. These significant factor loadings are often called salient loadings and can be obtained using a variety of methods. The first method is based on heuristics rather than mathematical rigour and simply relies on the magnitude of the loading being greater than 0.3. The second method is based on loadings being correlation coefficients, and uses statistically significant confidence levels. With a 99 per cent confidence level and a sample size of 125, the minimum value for a significant correlation and hence salient loading is 0.233 (Fisher 1965).

Burt (1952) reports the Burt-Banks formula which takes account of sample size, the number of test items and the number of factors extracted. The method is based on the premise that the value of the salient loading should increase with the higher factors. The method uses the above significant correlation to determine the base salient loading level, i.e. 0.233, and corrects for each factor using the following:

$$\sqrt{\frac{n}{n + 1 - r}}$$

where n is the sample size and r is the factor number.

The level of salient loading for the tenth factor is therefore

$$0.233 * \sqrt{42 / (42 + 1 - 10)} = 0.263.$$

The minimum salient loadings have been calculated for each factor using this method and are listed in table 6.8.

Table 6.8 - Salient factor loadings

Factor	Min. loading	Factor	Min. loading
1	0.233	6	0.248
2	0.236	7	0.252
3	0.239	8	0.255
4	0.242	9	0.259
5	0.245	10	0.263

Factor loadings

Factor analysis using the Varimax orthogonal rotation is reported in table 6.9 on the next page. The above criteria were used to provide the salient loadings for the first six factors. Using the Varimax solution only the first five factors provide evidence of communality of the test items. The loadings for higher factors do not help in clarifying the relationships between test items and factors; as such they are not reported. The loadings from the pattern matrix of an Oblimin oblique rotation have also been included to see if a clearer solution exits. In order to simplify the presentation of the table decimal points have been omitted. A value of 636 represents an actual loading of 0.636 and -306 represents -0.306.

Inspection of the Varimax solution shows that the loadings on the first and strongest factor include all items for surface learning, including both motive and strategy questions. The loadings on the six motive items and six strategy items confirms Biggs' SPQ for the Polytechnic sample of students with regard to surface learning. Another way of expressing this is that analysis of the first set of seven items (questions 1, 7, 13, 19, 25, 31 and 37) confirms that the questionnaire provides an indication of a common factor throughout the student group. This factor is known as the surface motive. A similar argument applies to the next set of questions on surface strategy.

A further interesting point from this analysis is that the first factor loads on both of the first two sets of questions. This confirms that these twelve questions measure a common behavioral pattern which is surmised to be surface learning. The single factor loading, as opposed to two separate factors, further indicates that there is a strong correlation between surface motive and surface strategy. This correlation is presented and discussed in the following section 6.1.4.

Table 6.9 - Salient loadings using Varimax and Oblimin rotations

		Varimax Loadings						Oblimin Loadings					
		Factors						Factors					
	Ques.	1	2	3	4	5	6	1	2	3	4	5	6
Surface Motive	1	636						679					
	7	749					-306	743				-266	
	13	805	-251					653		-252			
	19	709						689					
	25	470											
	31	696						458					
	37	731						582					
Surface Strategy	4	614						285					
	10	679						364					
	16	604											
	22	589						392			244		
	28	635						313					
	34	532											
	40	657				-249		349					
Deep Motive	2		531							384			
	8		436							293			
	14		700							666			
	20		595	247			283			448		321	
	26												
	32		817							783			
	38		704							690			
Deep Strategy	5		512			518				315			565
	11		341			685							730
	17		562			286				403			305
	23		394			572							607
	29		546	292					253	413			
	35		503	448		293			452	340			296
	41					677							696
Achieving Motive	3				738						751		
	9			271	711						704		
	15	297			426	323		257			364		366
	21						767					803	
	27	283			474		-285				489	-246	
	33				712						702		
	39				254								
Achieving Strategy	6			539					516				
	12			642			267		620				
	18			414			541		344			493	
	24			720					713				
	30			646					671				
	36			705					704				
	42			329					287				

Examination of factor two reveals that salient loadings occur in all but one of the deep motive and all but one of the deep strategy items within the SPQ. The previous arguments therefore apply to factor two with regard to deep learning. Factor two measures deep learning and also indicates that there is a correlation between the two sub-scales of deep motive and deep strategy. A further factor to emerge is the fifth which loads on six of the seven deep strategy items. This indicates that whilst factor two provides evidence of loading on overall deep loading, there is also a further independent factor that confirms the sub-scale of deep strategy.

The loadings on achieving learning provide a slightly different pattern to the above. Whilst there are loadings for achieving motive and achieving strategy, there is no single factor that binds the two together. All except one of the items within achieving motive load on factor number four and all of the items within achieving strategy load on factor three. This confirms the SPQ with regard to the measurement of the two separate independent scales of achieving motive and achieving strategy. However the correlation between the two does not appear to be as strong as those for both surface and deep learning.

Factor analysis using a Varimax orthogonal rotation confirms the robustness of Biggs' SPQ with regard to the sample of engineering students at Nottingham Polytechnic. Five factors emerged with regard to surface, deep and achieving learning. The oblique rotation using the Oblimin method does not add anything to this Varimax solution.

6.1.4 Learning strategy and motive correlations

Figures 6.6 to 6.8 show the relationship between strategy and motive for surface, deep and achieving learning respectively. The Pearson product moment coefficient of correlation (r-coefficient) is stated for each. This is the most common coefficient for measuring the *linear* relationship between two variables. Values can lie between -1 and +1, representing the range from a perfect negative to a perfect positive linear relationship. A value of 0 shows that there is no linear relationship. This does not mean that there is no relationship, just that there is no linear relationship. The Pearson correlation coefficient is therefore used to test the strength of a linear relationship between two variables. It is also used to measure the goodness of fit of data to a straight line law in which a linear relationship exists.

A low coefficient does not necessarily mean that there is no linear relationship, just that the relationship is weak. It is possible to statistically test whether there is a relationship. This can be carried out using the null hypothesis that there is no relationship. The probability of this null hypothesis can then be tested and the level of confidence of a linear relationship, albeit a weak relationship, can be obtained. The reliability of the correlation coefficient is tested by this hypothesis, and provides an indication of the quality of the correlation statistics. Any coefficient of correlation that is not zero and that is also statistically significant denotes some degree of linear relationship between the two variables.

A measure of the degree of variability of the dependent variable that can be explained by the independent variable is obtained by use of the coefficient of determination. This important coefficient is simply the square of the correlation coefficient (r squared). For example if the correlation between a particular learning strategy and motive is 0.7 then $r^2 = 0.49$. This means that nearly 1/2 (49 per cent) of the variability of the learning strategy can be explained by the corresponding motive.

Surface learning

Figure 6.6 plots surface strategy scores against surface motive scores for the total sample of engineering students. The graph indicates a positive linear relationship between motive and strategy with, in general, high motive scores corresponding to high strategy scores and vice versa. The surface strategy scores increase as the surface motive scores increase. Although there is some spread of data the points generally show a fairly strong tendency to cluster around the straight line. The straight line represents the line of best fit through the data points using the method of least squares.

The correlation coefficient for the relationship between surface strategies and motives is 0.8. This indicates a strong correlation between the two variables. The level of confidence of this statement is highly significant being greater than 99 per cent. It can also be stated that 64 per cent of the variability of the strategy scores is explained by the motive scores. There is therefore a strong relationship between surface strategies and surface motives.

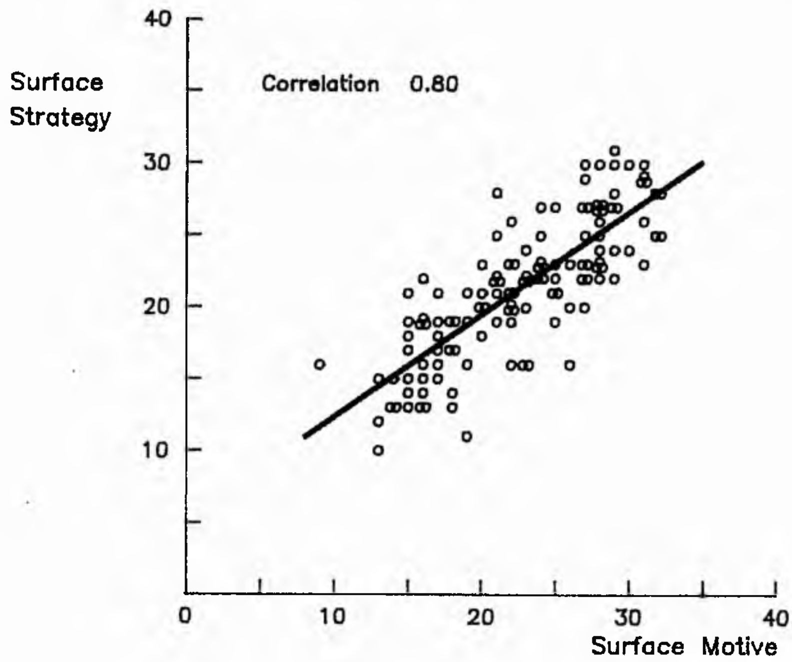


Figure 6.6 - Surface learning correlation

Deep learning

Figure 6.7 plots deep strategy scores against deep motive scores for the total sample of engineering students. Again the graph indicates a positive linear relationship between strategy and motive with strategy scores increasing as motive scores increase. Although there is some spread of data the points generally show a fairly strong tendency to cluster around the straight line.

The correlation coefficient for the relationship between deep strategies and deep motives is 0.72. Although the correlation is not as strong as for surface learning, this coefficient still indicates a strong correlation between the two variables. The level of confidence of this statement is highly significant being greater than 99 per cent. In this instance it can be stated that 52 per cent of the variability of the deep strategy scores can be explained in terms of the corresponding motive scores. There is therefore a strong relationship between deep strategies and deep motives.

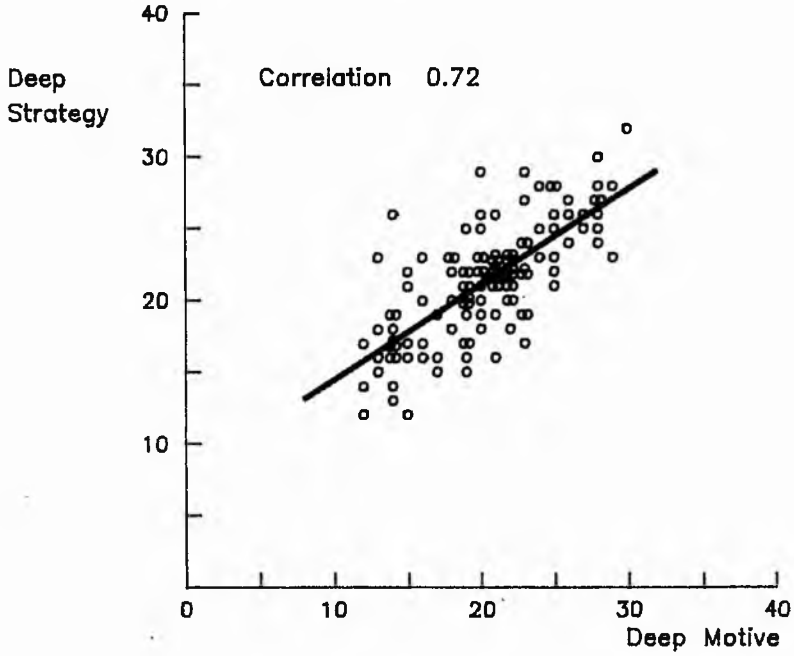


Figure 6.7 - Deep learning correlation

Achieving learning

Figure 6.8 plots achieving strategy scores against achieving motive scores for the total sample of engineering students. There is a considerable scatter of achieving data around the straight line. If a line was drawn around the points then it would result in more of a circular envelope compared to the elliptical envelope expected from a strong correlation. However, the plot generally indicates an increase in achieving strategy scores as the motive scores increase. There is therefore some indication of a positive linear relationship between the strategies and motives.

The correlation coefficient for the relationship between achieving strategies and achieving motives is 0.32. This correlation is considerably weaker than the surface learning and deep learning correlations. The coefficient does however indicate a weak correlation between the two variables. The level of confidence of this statement is highly significant being greater than 99 per cent. Although the correlation is weak the level of confidence indicates that some relationship exists and that the strategies and motives for achieving learning are not independent. In this instance it can be stated that only 10 per cent of the variability of the achieving strategy scores can be explained in terms of the corresponding motive scores.

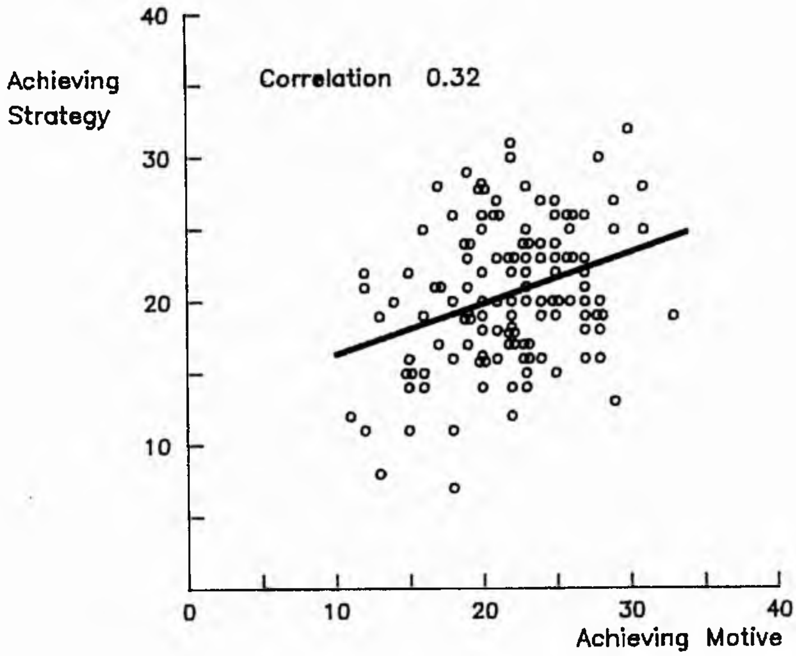


Figure 6.8 - Achieving learning correlation

General

The above indicates that there is a direct positive relationship between strategy and motive for all three type of learning. The correlations for surface and deep learning are strong, however the achieving learning shows only a weak correlation. All correlations are statistically very significant having confidence levels greater than 99 per cent.

The above analysis shows correlations within each of the three learning approaches. The next section investigates whether there is any direct relationship between the approaches i.e surface with deep or achieving learning. The correlations between surface, deep and achieving learning and their associated confidence levels were obtained using the SPSSX package. These correlations are reported in table 6.10 below. The respective strategies are correlated in the first part of the table and motives in the latter part.

Table 6.10 - Surface, deep and achieving learning correlations

	Surface strategy	Deep strategy	Achieving strategy
Surface strategy	1.0	-0.28	+0.21
Deep strategy	---	1.0	+0.24
Achieving strategy	---	---	1.0
	motive	motive	motive
Surface motive	1.0	-0.24	+0.25
Deep motive	---	1.0	+0.12
Achieving motive	---	---	1.0

The table shows that the correlations are not as strong as those within the separate learning approaches. With regard to strategies there is a weak negative correlation between the surface and deep strategies, whereas the correlation is positive between surface and achieving strategy scores. There is also a weak correlation between deep and achieving strategies. The above are all statistically significant at a level greater than the 99 per cent confidence level which indicates a high probability that these correlations exist. It is not expected that a student adopting a surface strategy would score highly on the deep strategy which can explain the negative correlation between the two. Whilst there is an indication of a positive relationship between achieving strategy with both surface and deep strategy, the coefficient is fairly low, albeit significant. The data indicates that students adopt an achieving strategy allied to either a surface or a deep strategy, but not to both at the same time.

The information in the table indicates a similar trend for learning motives as the above learning strategies and the same inferences can be drawn for these learning sub-scales. Again the correlations are weak but statistically significant at the 99 per cent level. The one exception is between deep and achieving motives in which the coefficient is very small and the confidence level is down to 90 per cent.

Similar weak but statistically significant relationships between the three overall learning approaches have also been found. Learning approaches are obtained by summing both motive and strategy scores. Overall, surface learning has a negative coefficient of -0.30 with deep learning and a positive coefficient of +0.3 with achieving learning. Finally deep learning also correlates positively with achieving learning having a coefficient of +0.22. The statistical confidence level of the correlation coefficients is at least 99 per cent.

6.2 Learning Styles

6.2.1 Comparison with Honey and Mumford data

This section presents an analysis of the activist, reflector, theorist and pragmatist styles, and compares the Polytechnic data with that collected by Honey and Mumford (1986a, 1986b). The Polytechnic data was obtained from the same 125 engineering students that were sampled for the learning strategy study reported in section 6.1, i.e. the sample of second year full-time and part-time students at Nottingham Polytechnic. The Honey and Mumford data selected for the comparison is based on two groups. The larger group consists of 925 respondents representing a wide cross section of managerial and professional people working in the UK industry. The second group consists of 73 engineering and science graduates. This smaller group was selected as being the closest group to the Polytechnic sample of students. However due to the relatively small sample size of this group (73 respondents) the larger group is also presented.

Norms have been produced by Honey and Mumford and are based on well over a thousand people. They suggest the following categories for the learning preferences:

- very strong preference => the highest 10 per cent
- strong preference => the next 20 per cent
- moderate preference => the middle 40 per cent
- low preference => the next 20 per cent
- very low preference => the lowest 10 per cent.

The Honey and Mumford distributions for all four learning styles are therefore 40 per cent, 20 per cent and 10 per cent for the moderate, strong, and very strong preferences respectively.

Figures 6.9 to 6.12 inclusive present the distribution of learning styles. For all four plots of learning style distribution the Polytechnic student data is shown as a solid line whereas the Honey and Mumford learning style data is represented by a broken line. With respect to this latter broken line, the data points for the total 925 respondents are shown separately to the scores for the 73 engineering and science responses. However it is considered that the data for these two groups is not sufficiently disparate to require two separate lines. A single broken line is therefore plotted through the Honey and Mumford data and acts as a basis for the comparison with the Polytechnic student sample. The different data points are identified and clearly highlighted on each of the four graphs.

Activist style

Figure 6.9 shows the comparison between the Polytechnic student sample and the Honey and Mumford sample for activist learning styles. The plot shows that there is a similar trend in the two sets of data with both cumulative frequency distributions having correspondingly shaped curves. The Polytechnic scores are slightly larger than the scores from the Honey and Mumford data; being typically 1-2 points higher for the major part of the graph.

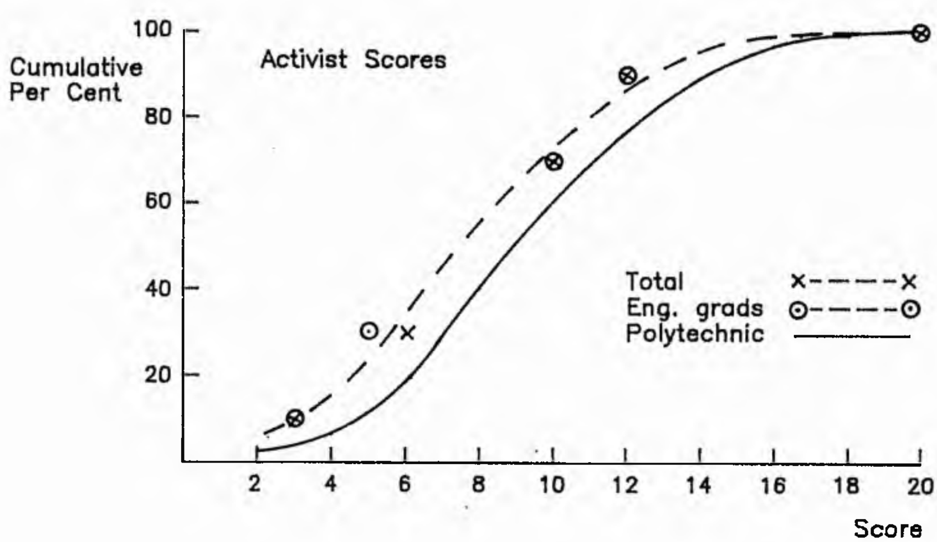


Figure 6.9 - Activist style distribution

The mean and standard deviation for each of the samples is presented for the activist style in table 6.11 below. Also included in the table is the percentage of respondents in each group that indicate activist style preferences. The data is presented in three categories being those with a moderate preference, those with a strong and those with a very strong preference to the activist style of learning. The preferences are based on the norms published by Honey and Mumford (1986a, 1986b) which are reproduced in section 4.2.3.

Table 6.11 - Activist styles

	mean score	SD	moderate per cent	strong per cent	very strong per cent
Polytechnic students	10.2	3.6	41.6	17.6	23.2
Honey and Mumford					
Total group	9.3	2.9	40.0	20.0	10.0
Eng. and Science	8.6	3.8	NP	NP	NP

NP - data not published.

Comparison of the means indicates that the activist scores for the Polytechnic student sample are higher than the two sets of Honey and Mumford samples. Based on a standard t test this difference in the means is statistically significant at the 99 per cent confidence level. The standard deviation for the Polytechnic sample of engineering students is greater than that for the Honey and Mumford total group. It is however similar to the smaller group of engineering and science graduates. There is therefore a greater spread of data in the two samples of engineering students and engineering and science graduates than the total Honey and Mumford sample.

The last three columns in table 6.11 display the number in each sample that have a preference towards the activist learning style. Moderate, strong and very strong preferences are shown in columns three to five respectively. The information is presented as percentages of the total respondents in each sample in order that comparisons can be made between the groups. For example, for the Polytechnic sample, there were some 42 per cent, 18 per cent and 23 per cent indicating a moderate, strong and very strong preference for the activist style respectively. Therefore a total of 83 per cent showed some preference to this style of learning with 41 per cent showing a strong or very strong preference. This compares with 70 per cent and 30 per cent respectively for the Honey and Mumford data.

The percentages of moderate and strong activist learning style preferences is similar for both the Polytechnic and Honey and Mumford samples. The Polytechnic sample shows considerably more students having a very strong preference being some 23 per cent of the sample which is approximately double the norm for this category.

Reflector style

Figure 6.10 below presents the reflector style scores. The graph shows that there is a similar trend in the two sets of data with both cumulative frequency distributions having correspondingly shaped curves. The Polytechnic scores are again slightly larger than the scores from the Honey and Mumford data, however the difference is not as marked as for the activist style scores.

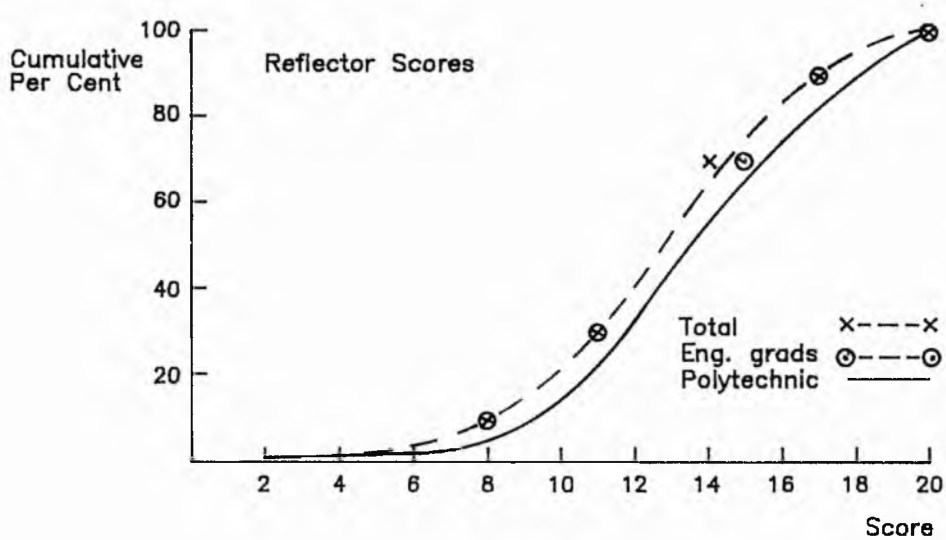


Figure 6.10 - Reflector style distribution

Further information concerning the mean and standard deviation for each of the samples and the percentage of students that indicated some preference towards the reflector style is presented in table 6.12 below. The reflector scores for the Polytechnic student sample are higher than the Honey and Mumford total sample. There is also a greater spread of reflector scores with this group. This difference in the means is statistically significant at the 99 per cent confidence level. However there is no statistically significant difference between the Polytechnic sample and the engineering and science graduate means and standard deviations.

In the Polytechnic sample, there were some 39 per cent, 22 per cent and 25 per cent indicating a moderate, strong and very strong preference for the reflector learning style respectively. Therefore a total of 86 per cent showed some preference to this style of learning with 47 per cent showing a strong or very strong preference. The numbers of moderate and strong reflectors is therefore similar to the Honey and Mumford samples. However, as for the activist data, the Polytechnic sample shows considerably more students having a very strong preference being some 25 per cent of the sample which is more than double the norm for this category.

Table 6.12 - Reflector styles

	mean score	SD	moderate per cent	strong per cent	very strong per cent
Polytechnic students	14.5	3.6	39.2	22.4	24.8
Honey and Mumford					
Total group	13.6	3.1	40.0	20.0	10.0
Eng. and Science	14.2	3.6	NP	NP	NP

NP - Data not published.

Theorist style

Theorist style scores are shown in figure 6.11. Again a comparison with the Honey and Mumford data is presented. For this learning style the plots indicate that there is little difference between the samples.

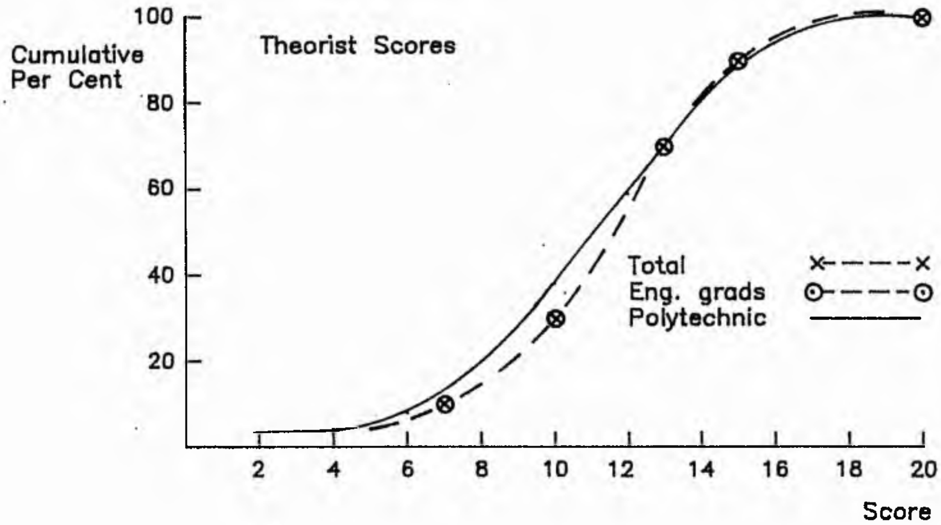


Figure 6.11 - Theorist style distribution

The means and standard deviations in table 6.13 below reinforces the above observation in that there is no statistically significant difference between the Polytechnic data and both sets of Honey and Mumford data.

Table 6.13 - Theorist styles

	mean score	SD	moderate per cent	strong per cent	very strong per cent
Polytechnic students	12.0	3.7	20.8	21.6	19.2
Honey and Mumford					
Total group	12.5	3.2	40.0	20.0	10.0
Eng. and Science	12.2	3.2	NP	NP	NP

NP - Data not published.

Detailed inspection of the percentage preferences towards the theorist style (moderate, strong or very strong) reveals subtle differences. As a proportion of the total sample there are more Polytechnic students showing a very strong preference than indicated by the Honey and Mumford norms. However the moderate preference comparison shows the opposite trend. This tends to indicate the sensitivity of the norm categories to small changes in style scores. The range of scores for a given category is relatively small. In particular the strong preference has a range of only two points (14 - 15). Someone who is in this category could therefore give an indication of either a very strong or a moderate preference by scoring 1 - 2 points higher or lower respectively. Answering a small number of questions differently would result in this discrepancy in style preference scores. The theorist data shows that there is a total of 62 per cent of the Polytechnic sample that indicate some preference towards the theorist learning style. The percentage having at least a strong preference is however some 41 per cent.

Pragmatist style

Data on the last of the four learning styles is presented in figure 6.12. This comparison of pragmatist styles shows that the Polytechnic sample of engineering students have lower scores than the Honey and Mumford groups. In particular the number of engineering students having low pragmatist preferences is distinct.

Initial observations of these low preferences is that the data does not agree with what might be expected of engineering students. Engineering is concerned with perceiving a particular need and satisfying that need. It is therefore, by its nature, a practical applications oriented profession and should appeal to the pragmatist. However, in general students arrive at the higher education stage having demonstrated the ability to study and meet academic criteria rather than by being proficient at perceiving and solving highly specific practical problems. Higher education for engineers involves a significant amount of project work to develop these skills through design and applied engineering assignments. Also the engineering sciences are taught through relevant engineering applications. However considerable analytical ability is still a necessary requirement of engineering education and students need to be mathematically adept and also proficient at passing examinations to succeed on their course of study. The need for this approach for successful study, and previous training in academic subjects, may well mitigate against the practical aspects of education and explain the relatively low preferences to the pragmatist style of learning. It would be interesting to compare the learning styles of this sample of students some ten years after they graduate.

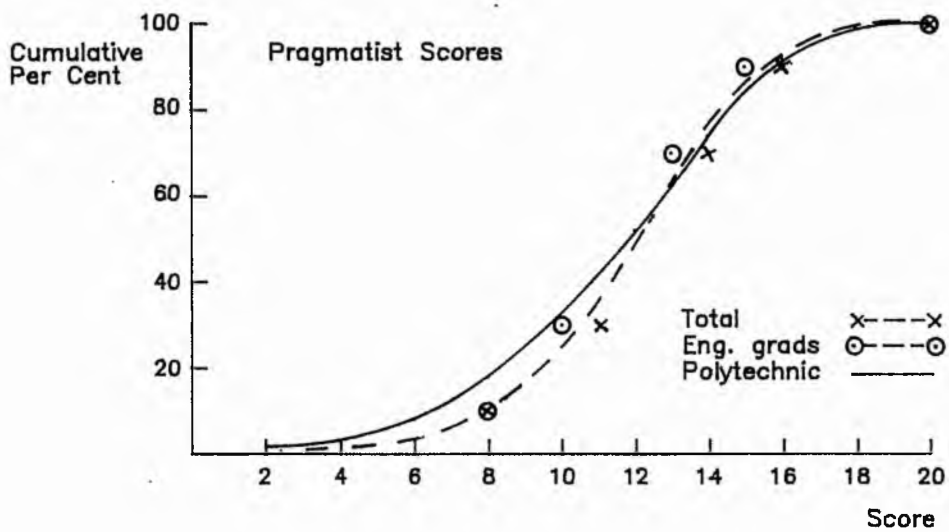


Figure 6.12 - Pragmatist style distribution

Table 6.14 presents further data on pragmatist learning styles. Comparison of the data shows that the differences in the means for the Polytechnic students and the total Honey and Mumford sample is statistically significant at the 99.9 per cent confidence level. However there is no statistically significant difference from the engineering and science graduates.

Table 6.14 - Pragmatist styles

	mean score	SD	moderate per cent	strong per cent	very strong per cent
Polytechnic students	12.3	3.6	39.2	17.6	8.0
Honey and Mumford					
Total group	13.7	2.9	40.0	20.0	10.0
Eng. and Science	12.7	3.0	NP	NP	NP

NP - Data not published.

There are some 18 per cent of the Polytechnic engineering students who indicated a strong preference and 8 per cent who demonstrated a very strong preference towards the pragmatist learning style. Furthermore there are approximately 35 per cent of these engineering students who obtained a low or very low preference towards this particular style.

The published norms for these two categories is 30 per cent when combined together.

General

Overall it is interesting to note the relatively high numbers of students in the category representing very strong preferences for the activist, reflector and theorist learning styles. Perhaps surprisingly within engineering courses this trend is not matched within the pragmatist style scores. The current pressures to move towards common skills and measurement of competencies as well as the greater emphasis on training may redress this balance. However the danger of these approaches is that they will develop the ability of students to do rather than to think. The danger of providing pure training within further and higher engineering education must be recognised and resisted. The need to provide graduates with engineering capability is clearly established and recognised, however the key word is *education* and engineering courses must provide vocational education and not training.

It is encouraging to find high levels of learning preference across the four different styles. Education is concerned with the development of personal skills alongside of technical and analytical capabilities. The development of all learning styles is an important part of this process in order that graduates can profit from differing learning situations in their future careers. In order to assess the global attributes of the students' learning styles, the percentages of students having strengths in one or more style has been investigated. Table 6.15 reports these percentages.

Table 6.15 - Multiple learning styles

	Very strong preference	Strong or very strong preference
Two styles (%)	12.0	32.0
Three styles (%)	1.6	14.4
Four styles (%)	0	2.4

The table shows the percentage of the total student sample who have preferences to more than one learning style. Almost a third (32 per cent) have either a strong or very strong preference in two styles. Some 14 per cent have similar preferences for three styles and only 2.4 per cent have a strong or very strong preference towards all four styles. Combining the data shows that nearly half (48.8 per cent) have a strong or very strong preference to two or more learning styles, whereas 16.8 per cent have these preferences towards three or more styles. The figures for very strong preference are shown in the first column of the above table.

6.2.2 Full-time and part-time differences

A comparison between full-time and part-time student learning motives and strategies is reported in section 6.1.2. This comparison revealed interesting trends which tended to support the hypothesis concerning the greater study motivation and commitment of part-time students. There are no similar obvious preconceived concepts with respect to learning styles of part-time students. However for completeness a comparison between the full-time and part-time learning styles has been carried out and is reported in this section.

Table 6.16 - Learning style scores by mode of study

	Activist		Reflector		Theorist		Pragmatist	
	mean	SD	mean	SD	mean	SD	mean	SD
Full-time group	10.5	3.6	14.8	3.7	11.8	3.8	12.2	3.3
Part-time group	9.5	3.6	13.4	3.2	12.5	3.2	12.9	4.6

Table 6.16 compares the mean learning style scores of full-time and part-time students. This table indicates that the full-time students' activist and reflector scores are higher than those for the part-time students. Conversely the full-time student scores for the theorist and pragmatist styles are lower than the part-time student scores. However analysis using standard t tests shows that the results are only statistically significant for the reflector learning styles, and this is only significant at the 90 per cent confidence level. Based on the Polytechnic sample of engineering students there is therefore

no strong evidence to suggest that the learning styles of full-time students are different to those of part-time students.

The percentage of students having learning preferences are shown in table 6.17 below for the two modes of study. Although the above analysis indicates little difference between mean scores, subtle differences in the numbers showing a strong or very strong preference in certain of the styles can be detected. There is little difference for the activist learning style. Based on the combined total numbers for strong and very strong preferences there is no marked difference for the theorist styles; the full-time group having some 40 per cent with a strong or very strong preference compared to 45 per cent of the part-time group. The distribution within these categories (strong and very strong) is however different with relatively more full-time students falling into the very strong preference category compared to the part-time group. The two remaining styles do however indicate differences.

Table 6.17 - Learning style preferences by mode of study

	moderate (%)		strong (%)		Very strong (%)	
	F/T	P/T	F/T	P/T	F/T	P/T
Activist style	44.8	31.0	17.7	17.2	24.0	20.7
Reflector style	36.5	48.3	19.8	31.0	30.2	6.9
Theorist style	18.8	27.6	19.8	27.6	19.8	17.2
Pragmatist style	41.7	31.0	14.6	27.6	6.3	13.8

The percentage having a strong or very strong preference for the reflector style is greater for the full-time group than the part-time group (50 per cent and 38 per cent respectively). Comparison of the pragmatist styles shows the opposite trend there being 41 per cent of the part-time group and 21 per cent of the full-time group falling into these two higher categories of learning style preference.

6.2.3 Learning style correlations

Based on the Polytechnic sample of engineering students a study has been carried out of the correlations between the four preferred learning styles. These correlations are reported in table 6.18 below.

Table 6.18 - Learning style correlations

	Activist	Reflector	Theorist	Pragmatist
Activist	1.0	-0.18	-0.19	0.17
Reflector	---	1.0	0.32	-0.05
Theorist	---	---	1.0	0.15
Pragmatist	---	---	---	1.0

The data shows that there is a weak positive correlation between the following groups:

Activist <=> Pragmatist

Theorist <=> Pragmatist,

and a weak negative correlation between:

Activist <=> Reflector

Activist <=> Theorist.

The above are all statistically significant at the 90 per cent confidence level except for the theorist/pragmatist correlation which is slightly below the 90 per cent level. The correlation of 0.32 between the reflector and theorist scores indicates a stronger relationship for these two preferred learning styles. The confidence level for this relationship being greater than 99 per cent.

Some of the activist engineering students may enjoy learning through role playing situations, business games and teamwork tasks. The weak negative correlations with the reflector and theorist styles suggests that some of these activists do not enjoy being forced to spend time reviewing and thinking about the past learning experiences and developing mathematical models, concepts and theories. However of the 51 students having a strong or very strong preference for the activist style of learning only 9 have a low or very low preference for the reflector style and 23 have similar preferences for the theorist style. There are 14 of these students who also have a strong or very strong preference towards the pragmatist style. The practical problem related situations that appeal to the pragmatist may well be associated with the need to carry out tasks that appeal to the activist. However of these 51 students, 20 and 18 have strong or very strong preferences to the reflector and theorist styles respectively. Despite the above statistical significance these figures reinforce that the weak negative correlations reported in table 6.18 above are of a tenuous nature.

Reflectors and theorists have common learning interests in that they both enjoy situations in which they have to spend time thinking about the material and carry out activities in which they have individual tasks involving reading and writing. Reflectors enjoy reviewing and thinking about past situations, whereas theorists enjoy having the opportunity to apply the knowledge gained in developing theories and concepts within a systems approach. There are 59 of the sample of engineering students having a strong or very strong preference to the reflector style and 51 having similar preferences to the theorist style. Of these 30 have a common strong or very strong preference to both styles of learning. This tends to reinforce the relationship between the learning preferences of reflectors and theorists.

6.2.4 Learning strategy and style correlations

To complete the learning correlations, the relationship between learning strategy and learning style has been investigated and is reported in table 6.19 below.

Table 6.19 - Learning approach and style correlation

	Activist	Reflector	Theorist	Pragmatist
Surface	0.15	0.12	0.16	0.12
Deep	0.07	-0.12	0.01	0.17
Achieving	0.07	0.05	0.23	0.24

The table, having generally low correlations, shows that there is little if any relationship between the four learning styles and the three approaches to learning. Most of the correlations are not statistically significant at the 90 per cent confidence level. There are weak correlations between those engineering students having either a theorist or pragmatist learning preference and the achieving approach. These two correlations are highly statistically significant having a 99 per cent confidence level. The correlations of surface learning with the activist and theorist styles have a 90 per cent confidence level as has the deep approach with pragmatist learning preference. However these correlations are all very weak being from 0.15 to 0.17.

Of the 45 students who indicated a surface approach to learning 21 and 20 have a strong or very strong preference to the activist and theorist learning styles respectively. However only 7 of the 25 having a deep approach also showed a preference to the pragmatist style. Of the 54 students with an achieving approach, 27 were theorists and 18 were pragmatists.

The evidence presented above suggests that the learning styles questionnaire (LSQ) measures different characteristics to the study process questionnaire, i.e. learning styles are different to learning strategies and motives. Although there is some indication of correlation between certain of the learning styles and strategies, the relationships are tenuous and not sufficient to indicate any firm links between styles and approaches. This supports the hypothesis that there is a distinction between learning styles and learning strategies. As stated in the literature review learning styles are concerned with a student's preference for learning methods whereas learning strategy is concerned with the way that a student chooses to tackle a particular learning task.

6.3 Assessment results

6.3.1 Comparison of continuously assessed and examination marks

Data has been collected on a variety of assessments for the sample of engineering students. These results are presented and discussed in chapter 5. The classification of the assessment types includes:

- examination
- continuous assessment
- design project
- computer aided design (CAD)
- aggregate.

The continuously assessed marks include both the design project and the CAD marks. These latter two were included for the reasons discussed in section 5.2.4. The aggregate mark for engineering students is used as one of the criteria for deciding whether students should progress to the next level of study on their respective course of study. This aggregate mark consists of contributions from the continuously assessed and from the examination marks. The weighting between the two types of assessment is different for each course.

The marks detailed in chapter 5 are summarised in the two figures below. The data is presented as the number of students who obtained marks within 10 per cent bandwidths. Figure 6.13 provides a comparison between the three main types of assessment; examination, continuous assessment and aggregate marks. The design project and CAD marks are compared in figure 6.14 using the continuously assessed marks as a basis.

Figure 6.13 clearly shows that the distribution of continuously assessed marks are higher than the examination distribution with 35 students obtaining at least 70 per cent and 57 obtaining marks within the range 60 to 69 per cent. This compares with the 9 and 18 students respectively in the corresponding bands for examination marks. The opposite trend is displayed at the lower end of the mark distribution. Approximately half of the student sample obtained examination marks less than 50 per cent, compared to some 5 per cent who obtained similar marks in the continuously assessed elements of the respective courses.

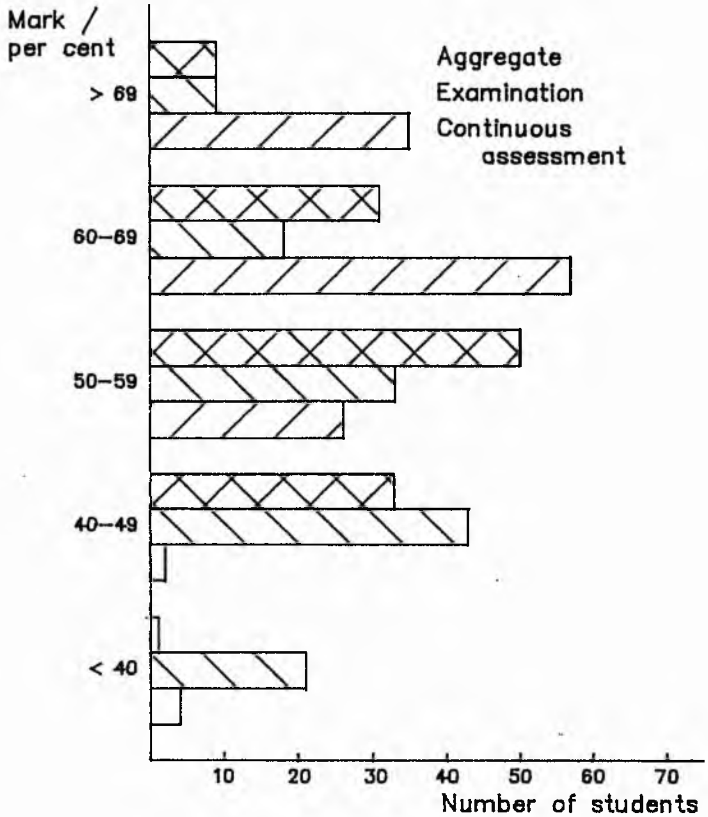


Figure 6.13 - Comparison of marks for different assessment types

Mean scores for the two types of assessment, reported in chapter 5, confirm the above. The continuously assessed mean mark of 64.1 per cent is statistically higher than the mean of 51.1 per cent for examinations. Correlating the two assessment types with the aggregate mark shows that there are strong positive relationships. The correlation coefficient for the continuously assessed and aggregate marks is 0.65. Similarly the examination and aggregate correlation coefficient is 0.93. Both correlations are statistically significant at the 99 per cent confidence level. Whilst both continuous assessment and examinations contribute directly towards the aggregate mark, on balance examinations still have a slightly greater influence on the decision concerning student progression at the end of the year.

Figure 6.14 compares the marks for project work and for the module in computer aided design (CAD) against the overall continuously assessed marks.

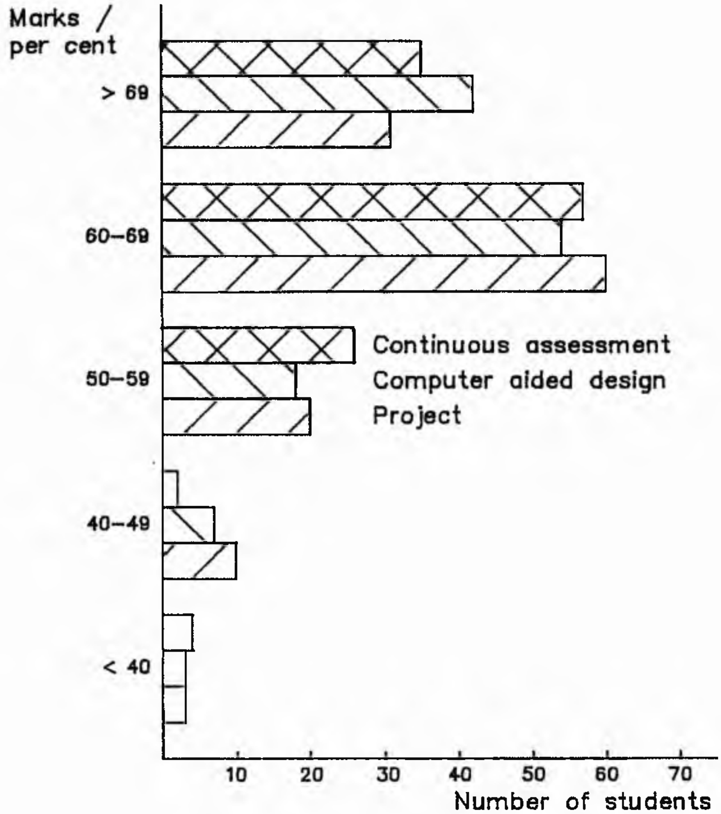


Figure 6.14 - Continuously assessed marks

The distributions for project and CAD marks are both very similar to the overall continuously assessed marks. The means for these marks are also very similar being 62.8, 64.8 and 64.1 for the project, CAD and continuously assessed marks respectively. Statistical analysis of these means, based on a confidence level of at least 90 per cent, shows that no difference can be detected between the three means. Surprisingly the correlations, shown below, are not as high as might be expected.

0.48	continuous assessment <=> project
0.45	continuous assessment <=> CAD
0.66	project <=> CAD.

From the above it is deduced that other pieces of work, including assignments and controlled set pieces, make a greater contribution to the overall continuous assessment mark.

6.3.2 Learning approaches and assessment

The three learning strategies and their associated motives have been correlated with the different types of assessment. Table 6.20 presents the information for all strategies and motives against all assessments.

Table 6.20 - Learning strategy/motive and assessment correlation

	Examination	Continuous Assessment	Design Project	CAD	Aggregate
Surface					
Strategy	0.08	0.10	0.09	0.03	0.09
Motive	0.05	0.19	0.23	0.11	0.10
Deep					
Strategy	-0.06	0.02	-0.14	-0.06	-0.04
Motive	-0.08	-0.01	-0.16	-0.04	-0.08
Achieving					
Strategy	0.03	0.18	0.05	0.05	0.10
Motive	-0.04	0.09	0.16	0.16	0.01

The only correlations that are statistically significant at a minimum confidence level of 90 per cent are:

surface motive <=> continuous assessment
surface motive <=> design project
deep motive <=> design project
achieving strategy <=> continuous assessment
achieving motive <=> design project
achieving motive <=> computer aided design.

There is no discernible pattern to the above correlations. The relationships reported are also generally very weak and do not indicate any real positive relationships between learning strategy or motive with student performance on assessments.

Table 6.21 - Learning approach and assessment correlation

	Examin-ation	Continuous Assessment	Aggregate
Surface	0.07	0.15	0.10
Deep	-0.08	0.00	-0.07
Achieving	0.00	0.17	0.07

A broader review of the relationships is provided in table 6.21 above, in which the examination mark, the overall continuous assessment and the aggregate marks are correlated with surface, deep and achieving learning approaches. These three approaches are obtained from the sum of the respective strategies and motives. Norms are available from the Biggs data for these approaches. This overall data reinforces the view that there is little correlation between the different approaches to learning and the mark that students obtain in the various types of assessment. An analysis of the learning approach and mean mark is also presented in table 6.22 below. The mean mark for those engineering students in the Polytechnic sample who have indicated an overall positive approach to surface, deep and achieving learning is shown. The data in this table represents the mean and standard deviation for surface, deep and achieving learners.

The mean aggregate mark for the total sample is 55.6 per cent with an associated standard deviation of 9.3 per cent. Standard statistical analysis has been carried out using t-tests to assess whether there is any difference between the mean for the whole group and the individual means shown for those students who are either surface, deep or achieving learners. Utilising a confidence level of 90 per cent the analysis shows that the mean aggregate mark for surface, deep and achieving learners is not different to the mean aggregate mark for the total group sample.

Table 6.22 - Marks related to learning approach

	Aggregate Mark	
	Mean	SD
Surface Learners	56.2	9.0
Deep Learners	53.6	7.1
Achieving Learners	57.5	8.5

This reinforces the evidence that, for the second year engineering students at the Polytechnic, there is little correlation between learning approach and performance.

6.3.3 Learning styles and assessment

An investigation into the effect of learning style on student performance has also been carried out. Student performance is measured using five assessment types as above. The learning style relationship with assessment marks is presented in table 6.23.

Table 6.23 - Learning style and assessment correlation

	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
Activist	-0.02	-0.17	0.07	-0.04	-0.06
Reflector	-0.07	0.04	-0.07	-0.16	-0.06
Theorist	0.31	0.36	0.16	0.18	0.36
Pragmatist	-0.06	0.05	0.01	-0.04	-0.01

The theorist scores are positively related to all of the assessment marks. The strongest correlation being with continuous assessment, examination and aggregate marks. These are statistically significant at the 99 per cent confidence level. The other two weaker correlations, with computer aided design and design project marks, have a 95 per cent and 90 per cent confidence level respectively. The only other relationships have negative correlations and are statistically significant at a minimum confidence level of 90 per cent. These are:

activist <=> continuous assessment
reflector <=> computer aided design.

A broader review of the relationships is provided in table 6.24 below. The mean mark and standard deviation of those students indicating either a strong or very strong preference to the activist style is shown in the first row of this table. This is followed by the mean and standard deviation for reflectors, theorists and pragmatists. the mean and standard deviation for the total sample is 55.6 per cent and 9.3 per cent respectively.

Table 6.24 - Marks related to learning style

	Aggregate Mark	
	Mean	SD
Activists	56.4	8.5
Reflectors	55.5	8.1
Theorists	59.9	8.1
Pragmatists	58.4	8.3

There is no statistically significant difference between the mean aggregate mark for the total student sample and the means for the activists, reflectors and pragmatists within the group. However the difference between this aggregate mean and that for the theorists is highly significant at the 99 per cent confidence level. This supports the above and suggests that theorists are most likely to succeed on the two engineering degree courses sampled at Nottingham Polytechnic.

Chapter 7:
Conclusions

You cannot help men by doing for them
what they should be doing themselves.
Abraham Lincoln

Chapter 1 - Conclusions

7.1 Conclusions

The conclusions set out in this chapter are drawn from the discussion of results in chapter 6. The first part presents the conclusions from the work on learning strategy. This is followed by learning styles conclusions and the inferences derived from the correlations between strategies, styles and student performance on various assessments. Differences between full-time and part-time students are included where relevant.

Conclusions based on a detailed investigation of the results of the data survey and analysis are presented. These are related to the objectives and hypotheses set out in the introduction.

7.1.1 Learning strategy

Comparisons

The first objective of the research was to determine the learning strategies of a representative sample of engineering students and to compare the results with previously published data. A comparison of the Polytechnic sample of engineering students with the data published by Biggs has been carried out. The Biggs group consisted of Australian male science students in Colleges of Advanced Education.

The following summarises the main conclusions to be drawn from the data on learning strategies and motives.

> For surface learning there is little significant difference between the two groups of students. Slightly more of the Polytechnic students exhibit a surface approach to learning with a relatively large proportion having surface motives.
>
> Overall, for deep learning, there is little significant difference between the two groups of students. The distribution of strategy scores is very similar, however the Polytechnic student deep motives are generally lower. There is a low level, some 20 per cent, of deep learners within the Polytechnic sample of engineering students.

Achieving learning results show a similar trend to the above categories of learning. There is little significant difference between the two groups of students. There is an encouraging level of achieving learning in the Polytechnic sample with over 40 per cent adopting a positive approach.

Comparing the two groups there are no major differences in learning approach, strategy and motive, except for the deep approach, in which the Polytechnic engineering students indicated consistently lower deep motive scores than the Biggs group of students.

Study mode

The learning strategies and motives of full-time and part-time student groups have been separately examined. The main aim of this comparison was to test the hypothesis that part-time students are more motivated than full-time students. This has led to the following conclusions.

The surface learning scores of the full-time students appear to be marginally higher than those for part-time students. A greater proportion of these full-time students have a positive tendency towards the surface learning approach.

The part-time group's deep learning mean scores are greater than those of the full-time group. Approximately twice as many part-time than full-time students have scores that indicate a positive approach to deep learning.

Achieving learning scores for the part-time students is only marginally higher than the full-time group scores.

Analysis of the assessment marks shows that the part-time group consistently obtained higher marks than the full-time group. The differences in the marks is statistically significant at a confidence level of at least 95 per cent.

The evidence from the survey using Biggs SPQ is that there is a higher level of surface learning within the full-time than within the part-time student group. As might be expected from this, the opposite trend is true for deep learning. With regard to achieving learning the results are inconclusive and there is no statistically significant difference between the two student groups. The higher levels of deep learning within the part-time student group associated with the higher levels of surface learning within the full-time student group partially explains the difference in performance on a variety of assessments.

Correlations

A generally accepted view is that the strategies that students adopt in their studies are directly related to their motives. The following conclusions from the analysis of the Polytechnic sample of engineering students tend to confirm this hypothesis. These correlations have been investigated using Pearson's product-moment coefficient.

> There is a strong positive relationship (0.80 coefficient) between student surface strategies and surface motives.
>
> Deep learning shows a similar strong correlation having a coefficient of 0.72.
>
> The correlation between achieving strategy and motive is however less strong. The correlation coefficient being only 0.32.

There is therefore evidence of a direct positive relationship between strategy and motive for all three types of learning. Although achieving learning is the weakest of the correlations, the result is significant at a high level of confidence.

The above correlations were obtained from the Biggs SPQ data. A factor analysis of the Polytechnic student responses to the SPQ has been carried out. This enables conclusions to be drawn with respect to the validity and internal consistency of the questionnaire. The factor analysis of the Polytechnic data from Biggs' SPQ confirms the internal consistency of items with respect to surface, deep and achieving learning. The loadings show consistency of student response for overall surface and overall deep learning approaches, and for achieving strategy and achieving motive separately.

To complete the analysis of correlations an investigation of the relationships between the different learning approaches was carried out. This did not reveal any strong correlations. There is an indication of a negative relationship between surface and deep learning, and positive relationships between achieving learning and both surface and deep learning. These correlations are however quite weak.

7.1.2 Learning style

Comparisons

The next set of objectives within the research was related to the learning styles of a representative group of engineering students. The learning styles of the Polytechnic sample of engineering students has been determined and compared with the data published by Honey and Mumford. The data compared was based on a small group of engineering and science graduates as well as a large group of managers in the UK industry. Generally this comparison shows that there is not a great divergence between the distributions of learning styles of the Polytechnic engineering students and the learning styles of both groups sampled by Honey and Mumford.

A detailed investigation of the activist, reflector, theorist and pragmatist styles reveals some slight differences. These are presented below.

> The activist data indicates that the Polytechnic students have higher activist scores than the two Honey and Mumford groups. There are some 23 per cent of this group with a very strong activist preference, which is approximately double the expected norm for this learning style.
>
> Although not as marked as the activist results, the data on reflector styles indicate slightly higher scores for the Polytechnic students. The Polytechnic students have a higher mean reflector score when compared to the managerial group. However there is no statistically significant difference with the results for the engineering and science graduates. As for the activist style there is approximately double the expected norm for the reflector learning style.

The distribution of theorist scores indicates that there is little difference between the Polytechnic students and the two Honey and Mumford groups. There is no statistical difference between the mean theorist scores.

A different trend was observed with the pragmatist learning styles. The Polytechnic students have a lower distribution of scores than the managerial group. However there is no statistical difference when comparing the Polytechnic engineers and the engineering and science graduates sampled by Honey and Mumford.

Although there were some minor differences between the Polytechnic sample and the Honey and Mumford managerial group, the scores for the subset of engineering and science graduates is not significantly different. Overall the comparison shows that the Polytechnic students have a tendency towards activist learning. There are no major differences between the Polytechnic sample and the Honey and Mumford published data on learning styles.

An analysis of multiple styles shows that almost half of the Polytechnic students indicated a strong or very strong preference to two or more learning styles, some 17 per cent have similar preferences to three or more styles and 2 per cent have a strength in all four styles.

Study mode

An appraisal of the learning styles for different modes of study did not reveal any major differences in the learning styles of full-time and part-time students. The mean reflector scores are higher for the full-time students at the minimum statistical confidence level of 90 per cent. This is not repeated for any other learning style. On this basis there is no evidence to suggest that the learning styles of the full-time engineering students are different to the corresponding part-time group.

Correlations

Whilst there is no strong argument for anticipating there to be correlations between learning styles, these relationships have been investigated for consistency with the learning strategy evaluation. Although there were no strong correlations some statistically significant results were observed.

> A weak positive correlation exists between the activist and pragmatist styles as well as between the theorist and pragmatist styles. These correlations are 0.17 and 0.15 respectively and have a 90 per cent confidence level.
>
> Weak negative correlations exist between the activist and both the reflector and theorist styles. The correlations are -0.18 and -0.19 respectively and have a 90 per cent confidence level.
>
> A stronger correlation of 0.32 exists between reflector and theorist styles, being significant at the 99 per cent confidence level.

The view of this author is that learning strategy is different to and independent of learning style. To test this assumption the relationships between learning strategy and learning style have been investigated. This generally showed that there was little correlation between any of the learning approaches (surface, deep or achieving) and the four learning styles. The only significant association was a weak correlation observed between achieving learners and theorists (0.23) and pragmatists (0.24).

Whilst there is some evidence of correlation between certain learning approaches and learning styles, these relationships are very weak. The relationships are tenuous and do not support any firm connection between learning approach and style. This supports the hypothesis that the learning styles questionnaire measures different characteristics to the study process questionnaire and that learning styles are different to learning approaches (strategies and motives).

7.1.3 Strategy/style and assessment

The final part of the conclusions reports on the relationships among learning approach (strategy and motive), learning style and student performance on assessment. The assessments are classified into the two main categories of examination and continuous assessment, which when combined form an overall aggregate mark. This aggregate is used for the purpose of grading and to assist in decisions regarding student progression on a course. Initially the relationships between the assessment types is reported.

> Continuously assessed marks are significantly higher than examination marks. The difference in the mean marks being greater than 10 per cent.
>
> There is a strong positive correlation between the continuously assessed marks and the aggregate marks (0.65 coefficient). The relationship between the aggregate and the examination marks is however stronger having a correlation coefficient of 0.93).
>
> Within the continuously assessed marks there is little difference between the CAD, project and overall marks.

Learning strategy

The main aim of a deep or achieving approach to learning is to obtain an understanding of study material which should then lead to better results in assessments. In order to investigate this hypothesis the relationships between learning strategy and learning motive with assessment marks were studied.

> The following correlation coefficients were observed, however they are weak and only significant at a 90 per cent confidence level:

surface motive - continuous assessment	0.19
surface motive - design project	0.23
deep motive - design project	-0.16
achieving strategy - continuous assessment	0.18
achieving motive - design project	0.16
achieving motive - computer aided design	0.16.

This shows that there is little correlation between any of the learning approaches and the results obtained by the students on the various assessments. The mean marks for surface, deep, and achieving learners were also compared and it was found that the marks are not statistically different.

There is no clear discernable pattern to suggest a link between either learning strategy or learning motive with assessment performance. The analysis shows no clear relationship between a student's approach to learning measured by the Biggs SPQ and the marks obtained on the various assessments. Anecdotal evidence suggests that other factors may have an overriding effect on the results and mask the above relationships. In particular the high student workload on engineering courses may cause deep and achieving learners to adopt a surface approach in order to enable the next assignment deadline to be met. Also teacher style may have a significant effect on student study methods. These aspects of student learning were not studied within this particular research project but could form the basis of future work on learning strategies and styles.

Learning style

A clearer pattern emerges from the investigation of the relationships between learning styles and assessment marks.

> The theorist learning style scores were found to correlate with examination, continuous assessment and aggregate marks at a statistical confidence level of 99 per cent. The correlation coefficients being 0.31, 0.36 and 0.36 respectively.
>
> The correlation with design project and CAD marks with the theorist scores were however weaker and statistically less significant.
>
> No other major relationships were obtained.

The mean aggregate marks for the theorists in the student sample were found to be higher than for the remaining groups (activist, reflector and pragmatist). The difference in the mean between this group and the other three groups was statistically very significant at a 99 per cent confidence level. The above suggests, with the present structure of the two engineering courses at Nottingham Polytechnic, that theorists are the most likely group to succeed in engineering at Nottingham.

7.2 Further Work

The research project reported in this thesis has proposed a learning model and an expert system to manage and provide advise on learning. A module on learning style assessment, incorporating the Honey and Mumford learning styles questionnaire, has been developed. A further expert system has been developed outside of the project. This concerns the assessment of undergraduate projects. The next stage is to develop other modules within the system. Eventually it will be necessary to integrate the various modules within an overall management shell.

The learning strategies and styles of a sample of second year engineering degree students within the department of Mechanical Engineering have been obtained and reported. Further work needs to be carried out to determine whether the findings are applicable to other years of the same courses and across other courses within the Faculty of Engineering. Comparisons need to be made with BEng undergraduates and post graduate students as well as with BTEC national diploma and certificate students. The comparisons between modes of study could be extended and a study of the differences in the learning approaches and styles of male and female students contrasted.

A linear study of the learning approach and style of a single cohort of students would provide valuable information on the effect of a course at different stages, including the work experience aspect of a sandwich degree. Changes in learning habits over the span of a course would provide information as to whether the desired learning approaches and styles are being developed. It would also be useful to obtain information on recently qualified engineers to determine the effects of professional development on these learning approaches and styles.

The research work could be extended to other courses within different Faculties of the Polytechnic with the aim of comparing students of different backgrounds as well as studying the differing effects on learning habits of the operation and structure of a course. It would also be useful to broaden the study to other Polytechnics and include Universities to study learning culture and its effects on students.

Comparisons have been made between the Polytechnic engineering students and Australian students. This work could be extended to include other countries having distinctive cultures. As part of this work the author has discussed the extension of the project with Hong Kong Polytechnic. As the result of these discussions there is a proposal to study the learning approaches and styles of Hong Kong Polytechnic engineering students and compare the findings to those reported in this thesis.

It is also proposed to extend the work at Hong Kong Polytechnic to include a study of the effect of student workload on learning approaches. As part of this study a student logbook (Pomfret and Wong, 1992) has been developed. This logbook is reproduced in appendix 5. Student workload and its consequences on effective study are important issues in engineering education. This work could therefore be extended to engineering courses at Nottingham Polytechnic.

The work reported in this thesis does not provide evidence of correlation between learning approaches and performance on assessments. It is suggested that the student workload may mitigate against deep and achieving approaches. The proposed further work, outlined above, on student workload should address this area.

Although some students declare a deep or achieving approach, they may not have the experience or expertise to apply these techniques. Positive intervention with students in the form of tutorials on study skills allied with the use of reflective journals could improve the effectiveness of student learning. Further work could involve a study of the effects of these interventions on student attitude, motivation and learning approach.

A computer based package could further be developed covering these study skills and interventions. This would aim to promote the type of study skills above rather than student 'survival skills' such as note taking, examination technique, communication skills, etc. Although these secondary skills might be included in the package, the main intention would be to develop real study skills and a deep approach to learning. The development and evaluation of such a system, following implementation within a course, would provide valuable information on effective and efficient student learning methods.

Appendices

He liked those literary cooks
who skim the cream of other's books
and ruin half an hour's graces
by plucking bon-mots from their places.

Hannah More

Appendices

Appendix 1 - References

A1.1 Education

A1.2 Artificial Intelligence

A1.3 Bibliography

Appendix 2 - Learning Styles Inventory : Knowledge Base

Appendix 3 - Learning Inventories

Biggs Study Process Questionnaire

Honey and Mumford Learning Styles Questionnaire

Appendix 4 - Learning Strategies/Styles and Performance Data

Appendix 5 - Student Workload Logbook

Appendix 6 - Published Papers and Conferences

Appendix 1 - References

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Appendix 2 - Learning Styles Inventory : Knowledge Base

******* Main Rule Set *******

```
/*  Program Name: LSI1
/*
/*  Author:       M J Swannell
/*
/*  Address:      Nottingham Polytechnic
/*                Department of Mechanical Engineering
/*                Burton Street
/*                NOTTINGHAM
/*                NG1 4BU
/*
/*  Telephone:    (0602) 418418 Ext 2331
/*
/*  ==================================================
/*
/*  --------- LEARNING STYLES INVENTORY --------
/*            ========================
/*
/*  Runtime controls
       control private

/*  Set goal
       seek learning_style

/*  Obtain current date display banner
/*  opening credits and obtain user data
       if heading is 'Nottingham Polytechnic'
       then run proc_date(curr_date);
            run screen1();
            run proc_banner(heading);
            use opening_credit;
            use opening_statement;
            use user_input_screen

/*  Initialise learning style scores
       if query is start
       then activist = 0;
```

```
            theorist = 0;
            reflector = 0;
            pragmatist = 0;
       preference is LOW

/*  Start consultation through object "proc_questions"
/*  End consultation when "learning_style" is known
/*  and display report to user
       if start is yes then
          run proc_questions(heading,question,style,
                                          activist,theorist,
       reflector,pragmatist,ques_no);
          run proc_style_graph(activist,theorist,
                                       reflector,pragmatist,
       surname);
          hold;
       graph is done

/* Determine which reports to display to user depending on score

       if activist > 6 then
          run proc_preference(activist,6,10,12,preference);
          use act_scrn1;
          use act_scrn2;
       act_result is done

       if theorist > 10 then
          run proc_preference(theorist,10,13,15,preference);
          use the_scrn1;
          use the_scrn2;
       the_result is done

       if reflector > 11 then
          run proc_preference(reflector,11,14,17,preference);
          use ref_scrn1;
          use ref_scrn2;
       ref_result is done

       if pragmatist > 11 then
          run proc_preference(reflector,11,14,16,preference);
          use pra_scrn1;
```

```
              use pra_scrn2;
          pra_result is done

/* Write results down to database file "lsdata.dbf"

          if ques_no > 40 then
            run proc_database_save(activist,theorist,
                                        reflector,pragmatist,
        course_year,surname,course,curr_date);
          data is done

/* Determine whether option to print hard copy reports is
   needed.
/* Decision is found using screen conc_scrn.

if activist>6 or theorist>10 or reflector>11 or pragmatist>11
then
            use conc_scrn;
condition is done

if activist<7 and theorist<11 and reflector<12 and pragmatist<12
then
answer is 'n'

/* If hard copy required procedure "proc_hard_copy" is executed

          if answer is 'y' then
            run proc_hard_copy(activist,theorist,
                                       reflector,pragmatist);
          hard_copy is known

          if answer is not 'y' then answer is 'n'

/* Set up cycling of knowledge base and query stop or continue
/* with a new run. Maximum number of cycles is defined by
   numeric object
/* cycle_limit currently set at 10

          use rerun_scrn

          IF start is yes then cycle_limit=10
```

```

        if cycle is STOP
        then cycle_mode is stop;
             learning_style is known

        if cycle is RERUN
        then cycle_mode is autocycle;
             learning_style is known
```

***** List of Objects *****

1 :	learning_style	Text
2 :	heading	Text
3 :	proc_date	Procedure
4 :	curr_date	Text
5 :	screen1	Procedure
6 :	proc_banner	Procedure
7 :	opening_credit	Screen
8 :	opening_statement	Screen
9 :	user_input_screen	Screen
10 :	query	Text
11 :	activist	Real
12 :	theorist	Real
13 :	reflector	Real
14 :	pragmatist	Real
15 :	preference	Text
16 :	start	Text
17 :	proc_questions	Procedure
18 :	question	Undefined
19 :	style	Undefined
20 :	ques_no	Real
21 :	proc_style_graph	Procedure
22 :	surname	Text
23 :	hold	Undefined
24 :	graph	Text
25 :	proc_preference	Procedure
26 :	act_scrn1	Screen
27 :	act_scrn2	Screen
28 :	act_result	Text
29 :	the_scrn1	Screen
30 :	the_scrn2	Screen
31 :	the_result	Text
32 :	ref_scrn1	Screen
33 :	ref_scrn2	Screen
34 :	ref_result	Text
35 :	pra_scrn1	Screen
36 :	pra_scrn2	Screen
37 :	pra_result	Text
38 :	proc_database_save	Procedure
39 :	course_year	Real

40	: course	Text
41	: data	Text
42	: conc_scrn	Screen
43	: condition	Text
44	: answer	Text
45	: proc_hard_copy	Procedure
46	: hard_copy	Text
47	: rerun_scrn	Screen
48	: cycle_limit	Real
49	: cycle	Text
50	: cycle_mode	Text
51	: initials	Text

******* Object Frames *******

Object Number : 3

```
          Name: proc_date
          Type: Procedure
   ReturnsText: curr_date
          Body:

/*  Retrieves system date/time i.e. 11-Jan-90  10:00
/*  and concatenates to date   i.e.11-Jan-90

         curr_date = date
         curr_date = mid(curr_date,1,9)
         return
```

Object Number : 5

```
          Name: screen1
          Type: Procedure
     LocalReal: i,j
          Body:
            grsense(0)
            grexecute('bgnd',17)
/* outline box
            grexecute('boxo',190,40,460,240,15)
/* frame outline
            grexecute('paint',17,22,24,60,15)
            grexecute('line',168,220,168,340,17)
            grexecute('line',169,220,169,340,17)

            grexecute('line',170,20,480,20,15)
            grexecute('line',170,240,480,240,15)
            grexecute('line',170,240,170,20,15)
            grexecute('line',480,20,480,335,15)
/* fill frame
            grexecute('fill',320,21,15,15)
/* horizontal step lines
            grexecute('line',406,60,460,60,15)
            grexecute('line',352,96,406,96,15)
            grexecute('line',298,132,352,132,15)
            grexecute('line',244,168,298,168,15)
            grexecute('line',190,204,244,204,15)
```

```
/* sloping step lines
            grexecute('line',406,60,460,80,15)
            grexecute('line',406,96,460,116,15)
            grexecute('line',352,96,460,136,15)
            grexecute('line',352,132,460,172,15)
            grexecute('line',298,132,460,192,15)
            grexecute('line',298,168,460,228,15)
            grexecute('line',244,168,430,240,15)
            grexecute('line',244,204,337,240,15)
            grexecute('line',190,204,283,240,15)
/* lines making worm starting from left hand end; in groups of long
/* curves and tight curves
            grexecute('line',190,80,203,72,15)
            grexecute('line',202,73,217,65,15)
            grexecute('line',217,65,230,62,15)
            grexecute('line',230,62,245,60,15)
            grexecute('line',245,60,250,62,15)
            grexecute('line',245,61,250,63,15)
            grexecute('line',250,62,252,64,15)
            grexecute('line',250,63,251,65,15)
            grexecute('line',252,64,252,65,15)
            grexecute('line',251,64,251,65,15)
            grexecute('line',252,65,250,68,15)
            grexecute('line',251,65,250,67,15)
            grexecute('line',250,67,240,78,15)
            grexecute('line',240,78,232,88,15)
            grexecute('line',232,88,225,99,15)
            grexecute('line',225,99,220,110,15)
            grexecute('line',220,110,223,113,15)
            grexecute('line',223,113,228,114,15)
            grexecute('line',228,114,230,112,15)
            grexecute('line',230,112,249,90,15)
            grexecute('line',249,90,268,74,15)
            grexecute('line',268,74,287,65,15)
            grexecute('line',287,65,305,60,15)
```

```
            grexecute('line',305,60,310,62,15)
            grexecute('line',310,62,311,65,15)
            grexecute('line',311,65,310,68,15)

            grexecute('line',310,68,305,73,15)
            grexecute('line',305,73,295,85,15)
            grexecute('line',295,85,287,96,15)
            grexecute('line',287,96,280,110,15)

            grexecute('line',280,110,283,113,15)
            grexecute('line',283,113,288,114,15)
            grexecute('line',288,114,290,112,15)

            grexecute('line',290,112,320,90,15)
/* fill steps
            grexecute('fill',430,61,15,15)
            grexecute('fill',370,97,15,15)
            grexecute('fill',320,133,15,15)
            grexecute('fill',270,169,15,15)
            grexecute('fill',220,205,15,15)
/* text
            grmessage('Knowledge Systems Centre',17,218,27,1,1)
            grmessage('Nottingham',34,194,250,3,4)
            grmessage('Polytechnic',34,180,290,3,4)

            grpause(0)
            grclose(0)
```

Object Number : 6

```
       Name: proc_banner
       Type: Procedure
 AcceptsText: heading
       Body:

/* Inserts the Nottingham Polytechnic banner centred
/* on the top line.
/*
         screen(27)
         colour(1,1,1,80,49)
         curloc(1,(80-len(heading))/2)
         print(heading)
         return
```

```
Object Number : 11
 1 :         Name: activist
 2 :         Type: Real
 3 :  QueryPrompt: never
 4 :   Form:
 5 :                       ************
 6 :                       * ACTIVIST *
 7 :                       ************
 8 :
 9 :         The results of your learning style questionnaire
10 :         show that you have a [preference] preference towards
11 :         the ACTIVIST approach to learning.
12 :
13 : ACTIVISTS involve themselves fully and without bias in new
14 : experiences.  They enjoy the here and now and are happy to be
15 : dominated by immediate experiences.  They are open-minded, not
16 : sceptical, and this tends to make them enthusiastic about
17 : anything new.  Their philosophy is:  I'll try anything once.
18 : They tend to act first and consider the consequences afterwards.
19 : Their days are filled with activity.  They tackle problems by
20 : brainstorming.  As soon as the excitement from one activity has
21 : died down they are busy looking for the next.  They tend to
22 : thrive on the challenge of new experiences but are bored with
23 : implementation and longer term consolidation.  They are
24 : gregarious people constantly involving themselves with others
25 : but, in doing so, they seek to centre all activities around
26 : themselves.
25 :
26 :
27 :               ACTIVISTS LEARN BEST FROM ACTIVITIES WHERE:
28 :
29 : *  There are new experiences/problems/opportunities from which
      to learn.
30 :
31 : *  They can engross themselves in short "here and now"
      activities such
32 :    as business games, competitive teamwork tasks and
33 :    role-playing exercises.
34 :
35 : *  They have a lot of the limelight, they lead discussions, give
36 :    presentations.
```

* They are allowed to generate ideas without restrictions of policy.

* They are thrown in at the deep end with a task they think difficult.

* They are involved with other people; solving problems as a team.

* It is appropriate to "have a go".

Object Number : 12

```
        Name: theorist
        Type: Real
 QueryPrompt: never
 Form:
                          ************
                          * THEORIST *
                          ************
```

The results of your learning style questionnaire show that you have a [preference] preference towards the THEORIST approach to learning.

THEORISTS adapt and integrate observations into complex but logically sound theories. They think problems through in a vertical, step by step logical way. They assimilate disparate facts into coherent theories. They tend to be perfectionists who won't rest easy until things are tidy and fit into a rational scheme. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories, models and systems thinking. Their philosophy prizes rationality and logic. "If it's logical it's good". Questions they frequently ask are: "Does it make sense?" "How does it fit with that?" "What are the basic assumptions?". They tend to be detached, analytical and dedicated to rational objectivity rather than anything subjective or ambiguous. Their approach to problems is consistently logical. This is their "mental set". They rigidly reject anything that doesn't fit with it. They prefer to maximise certainty and feel uncomfortable with subjective judgements, lateral thinking and anything flippant.

THEORISTS LEARN BEST FROM ACTIVITIES WHERE:

* The learning material is part of a system, model, concept, theory.

* They have time to explore the associations and relationships between ideas, events and situations.

* They have the chance to question and probe the basic methodology, assumptions and logic behind something.

* They are intellectually stretched, i.e. analysing a complex problem being tested in a tutorial session, being asked searching questions.

* They are in structured situations with a clear purpose.

* They can read or listen to ideas and concepts that are rational and logical.

* They can analyse and then generalise problems.

* They are offered interesting ideas and concepts even if not relevant.

Object Number : 13

```
        Name: reflector
        Type: Real
 QueryPrompt: never
 Form:
                        *************
                        * REFLECTOR *
                        *************

        The results of your learning style questionnaire
        show that you have a [preference] preference towards
        the REFLECTOR approach to learning.
```

REFLECTORS like to stand back to ponder experiences and observe them from different perspectives. They collect data, both first hand and from others and prefer to think about it thoroughly before coming to any conclusion. The thorough collection and analysis of data about experiences and events is what counts so they tend to postpone reaching definitive conclusions for as long as possible. Their philosophy is to be cautious. They are thoughtful people who like to consider all possible angles and implications before making a move. They prefer to take back seats in meetings and discussions. They enjoy observing other people in action. They listen to others and get the drift of the discussion before making their own points. They tend to adopt a low profile and have a slightly distant, tolerant unruffled air about them. When they act it is part of a wide picture which includes the past as well as the present and others' observations as well as their own.

REFLECTORS LEARN BEST FROM ACTIVITIES WHERE:

* They are allowed to watch/think/chew over activities.

* They are able to stand back and observe; observing a group at work, watch films/videos etc.

* They are allowed to think before acting and have time to prepare.

* They can carry out painstaking research, investigation and probing.

* They have time to review what has happened, what they have learnt.

* They are required to produce carefully considered analyses and reports.

* They are helped to exchange views within a structured learning experience.

* They can reach a decision without pressure within their own time.

Object Number : 14

Name: pragmatist

Type: Real

QueryPrompt: never

Form:

****

* PRAGMATIST *

****

The results of your learning style questionnaire show that you have a [preference] preference towards the PRAGMATIST approach to learning.

PRAGMATISTS are keen on trying out ideas, theories and techniques to see if they work in practise. They positively search out new ideas and take the first opportunity to experiment with applications. They are the sort of people who return from courses brimming with new ideas that they want to try out in practise. They like to get on with things and act quickly and confidently on ideas that attract them. They tend to be impatient with ruminating and open-ended discussions. They are essentially practical, down to earth people who like making practical decisions and solving problems. They respond to problems and opportunities "as a challenge". Their philosophy is: "There is always a better way" and "If it works it's good".

PRAGMATISTS LEARN BEST FROM ACTIVITIES WHERE:

* There is an obvious link between the subject and a practical problem.

* They are shown techniques that have obvious practical advantages.

* They have the chance to try out and practise techniques with an expert who can provide feedback.

* They are shown a model they can copy, a successful person, a film showing how something is done, etc.

```
*  They are given immediate opportunities to try out what they
   have learnt.

*  They are given good simulations and real problems to solve.

*  They can concentrate on practical situations.
```

Object Number : 17

```
         Name: proc_questions
         Type: Procedure
   AcceptsText: heading,question,style
  ReturnsReal: activist,theorist,reflector,pragmatist,ques_no
    LocalReal: i,row,col,ques_left
    LocalText:
        reply,ques_line_1,ques_line_2,ques_line_3,ques_line_4
         Body:
activist=0
theorist=0
pragmatist=0
reflector=0
/*  Clear banner and re-instate Nottingham Polytechnic heading
        screen(27)
        run proc_banner(heading)
/*  ----------------------------------------------------------

/*  Initialise variables
        ques_no = 1
        i = 1
/*  ----------------------------------------------------------

/*  Print user advice on answering questions to screen
        at(8,18,'You are required to answer either Yes or No')
        at(9,18,'to each of the questions.  You should decide')
        at(10,18,'on the response that most suits you.  There')
        at(11,18,'are no right or wrong answers.  The accuracy')
        at(12,18,'of the results depends upon how honest you
                                                        can')
        at(13,18,'be.  There is no time limit and it is not a
                                                      test.')
        at(14,18,'The questionnaire will take you
                                              approximately')
```

```
        at(15,18,'10-15 minutes.')
        hold
      /*  Blank above message
        repeat row(8,15)
           at(row,18,'                                        ')
        endrep
/*  Print Yes/No message and user instruction to screen
        box(15,36,17,40,2,0)
        at(16,20,'Enter Yes or No')
        at(16,37,'Y/N')
/*  Fetch and ask the 40 learning style questions
        repeat until (i gt 40)
           if ques_no lt 21 then
                 run
            get_first_quest(ques_no,ques_line_1,ques_line_2,  &
                                 ques_line_3,ques_line_4,style)
              else
                 run
            get_second_quest(ques_no,ques_line_1,ques_line_2, &
                                             ques_line_3,style)
           endif
         /*  Blank question area
           at(10,20,'                                         ')
           at(11,20,'                                         ')
           at(12,20,'                                         ')
           at(13,20,'                                         ')
         /*  Ask question
reply:     at(10,20,ques_line_1)
           at(11,20,ques_line_2)
           at(12,20,ques_line_3)
           at(13,20,ques_line_4)
         /*  Print message for the number of questions remaining
           ques_left = 40 - ques_no
           at(20,5,ques_left as 'xx',' questions remaining')
         /*  Get response and check if valid (Y/N)
           finput(reply,0)
           if reply eq 'Y' or reply eq 'y'&
```

```
                  or reply eq 'n' or reply eq 'N' then
               print(' ')
            else

            /*  Display user message for incorrect reply
               at(19,30,'*****************')
               at(20,30,'* WRONG RESPONSE *')
               at(21,30,'*****************')
               at(23,26,'Please enter either Yes or No')
               hold

             /*  Blank the WRONG RESPONSE message and re-ask
                 question
               repeat row(19,23)
                  at(row,26,'                              ')
               endrep
               goto reply:
         endif

      /*  Update counter and question number
         i = i + 1
         ques_no = ques_no + 1

      /*  Update learning style score
         if reply eq 'Y' or reply eq 'y' then
            if style eq 'act' then
               activist = activist + 1
            endif
            if style eq 'the' then
               theorist = theorist + 1
            endif
            if style eq 'ref' then
               reflector = reflector + 1
            endif
            if style eq 'pra' then
               pragmatist = pragmatist + 1
            endif
         endif

      endrep

```

```
/*  Factor learning style scores to bring into line
/*  original inventory based on 80 questions
        activist = 2 * activist
        theorist = 2 * theorist
        reflector = 2 * reflector
        pragmatist = 2 * pragmatist
        return
```

Object Number : 21

```
         Name: proc_style_graph
         Type: Procedure
  ReturnsReal: activist,theorist,reflector,pragmatist
  ReturnsText: surname
    LocalReal: i,axis,x1,y1,x2,y2
    LocalText: title,score
         Body:

/*  Test values
/*      activist = 4
/*      reflector = 16
/*      theorist = 13
/*      pragmatist = 17

/*  Initialise screen to EGA 'fast'
        grinit('fast')
/* Uppercase surname
        surname=uppercase(surname)

/*  Draw border around screen
        grexecute('boxo',0,0,638,348,7)
        grexecute('boxo',6,5,631,343,7)

/*  Draw axes for graph
        grexecute('line',148,184,468,184,3)
        grexecute('line',308,64,308,304,3)
/*  X-Axis ticks
        repeat,i(0,8)
           axis = i * 40 + 148
           grexecute('line',axis,184,axis,180,3)
        endrep
/*  Y-Axis ticks
```

```
          repeat,i(0,8)
             axis = i * 30 + 64
             grexecute('line',308,axis,314,axis,3)
          endrep
/*  Print title
          title = 'Learning Style Scores'
          grmessage(title,10,213,27,1,2)
/*  Print axis headings & norm scores
          grmessage('Activist',12,320,60,1,1)
          grmessage('Norm = 15',12,320,70,1,1)
          grmessage('Theorist',12,320,301,1,1)
          grmessage('Norm = 16',12,320,311,1,1)
          grmessage('Reflector',12,475,180,1,1)
          grmessage('Norm = 17',12,475,190,1,1)
          grmessage('Pragmatist',12,55,180,1,1)
          grmessage('Norm = 18',12,55,190,1,1)
/*  Print style scores
          score = activist as 'xx'
          score = 'Activist   ' + score
          grmessage(score,10,55,75,1,1)
          score = reflector as 'xx'
          score = 'Reflector  ' + score
          grmessage(score,10,55,85,1,1)
          score = theorist as 'xx'
          score = 'Theorist   ' + score
          grmessage(score,10,55,95,1,1)
          score = pragmatist as 'xx'
          score = 'Pragmatist ' + score
          grmessage(score,10,55,105,1,1)
/*  Draw activist to reflector line
          x1 = 308
          y1 = 64 + ((20 - activist) * 6)
          x2 = 308 + (reflector * 8)
          y2 = 184
          grexecute('line',x1,y1,x2,y2,12)
/*  Draw reflector to theorist line
          x1 = 308 + (reflector * 8)
```

```
        y1 = 184
        x1 = 308
        y1 = 184 + (theorist * 6)
        grexecute('line',x1,y1,x2,y2,12)

/*  Draw theorist to pragmatist line
        x1 = 308
        y1 = 184 + (theorist * 6)
        x2 = 148 + ((20 - pragmatist) * 8)
        y2 = 184
        grexecute('line',x1,y1,x2,y2,12)

/*  Draw pragmatist to activist line
        x1 = 148 + ((20 - pragmatist) * 8)
        y1 = 184
        x1 = 308
        y1 = 64 + ((20 - activist) * 6)
        grexecute('line',x1,y1,x2,y2,12)

/* Print instruction messages and name
grtext(25,3,'For print of graph press < SHIFT >-< PRINT SCREEN
>: Hit &
Any Key To Continue',7)
grtext(23,10,'Name: ',2)
grtext(23,16,surname,2)
        grpause(0)
        grclose(0)
return
```

Object Number : 25

```
         Name: proc_preference
         Type: Procedure
  AcceptsReal: style_score,mod_pref,strong_pref,very_strong_pref
  ReturnsText: preference
         Body:

/*  Clear screen at the start of each learning style message
        screen(27)

/*  Determines the level of learning style
/*  moderate, strong or very strong.
```

```
        If style_score gt very_strong_pref then
           preference = 'VERY STRONG'
           else
              if style_score gt strong_pref then
                 preference = 'STRONG'
                 else
                    preference = 'MODERATE'
              endif
        endif
        return
```

Object Number : 38

```
        Name: proc_database_save
        Type: Procedure
 ReturnsReal: activist,theorist,reflector,pragmatist,course_year
 ReturnsText: surname,course,curr_date
   LocalReal: length,i
   LocalText: filename,buffer,month
        Body:

       filename='lsdata.dbf'
       dbase(filename,1,buffer)

/* pad out surname to 18
       length=len(surname)
       repeat i(1,18-length)
          surname=surname+' '
       endrep
/* pad out course to 20
       length=len(course)
       repeat i(1,20-length)
          course=course+' '
       endrep

/* convert month to correct 2 digit format
       if mid(curr_date,4,3) eq 'Jan' then month='01'
       if mid(curr_date,4,3) eq 'Feb' then month='02'
       if mid(curr_date,4,3) eq 'Mar' then month='03'
       if mid(curr_date,4,3) eq 'Apr' then month='04'
       if mid(curr_date,4,3) eq 'May' then month='05'
```

```
        if mid(curr_date,4,3) eq 'Jun' then month='06'
        if mid(curr_date,4,3) eq 'Jul' then month='07'
        if mid(curr_date,4,3) eq 'Aug' then month='08'
        if mid(curr_date,4,3) eq 'Sep' then month='09'
        if mid(curr_date,4,3) eq 'Oct' then month='10'
        if mid(curr_date,4,3) eq 'Nov' then month='11'
        if mid(curr_date,4,3) eq 'Dec' then month='12'

/* store all data to buffer for database write
        buffer= surname + course + (course_year as 'x') +'19' &
+ mid(curr_date,8,2) + month + mid(curr_date,1,2)+(activist as 'xx') &
+ (theorist as 'xx') + (reflector as 'xx') + (pragmatist as 'xx')

/* write to database & close
        dbase(filename,7,buffer)
        dbase(filename,2,buffer)
        return
```

Object Number : 45

```
         Name: proc_hard_copy
         Type: Procedure
   AcceptsReal: activist,theorist,reflector,pragmatist
         Body:
                if activist gt 6 then
                   formprint(activist)
                   formfeed
                endif
                if theorist gt 10 then
                   formprint(theorist)
                   formfeed
                endif
                if reflector gt 11 then
                   formprint(reflector)
                   formfeed
                endif
                if pragmatist gt 11 then
                   formprint(pragmatist)
                   formfeed
                endif
                return
```

Nottingham Polytechnic
Faculty of Engineering

Biggs Study Process Questionnaire

Learning Strategies: Study Process Questionnaire (SPQ)

On the following pages are a number of questions about your attitudes towards your studies and your usual way of studying.

There is no **right** way of studying. It all depends on what suits your own style and the courses you are studying. The following questions have been carefully selected to cover the more important aspects of studying and we are surveying students in the Department of Mechanical Engineering in order to sample students' study attitudes and processes.

It is important that you answer each question. All answers will be **CONFIDENTIAL.** Individual responses will **NOT** be disclosed. Please complete the questionnaire as requested. Your cooperation is much appreciated.

How to answer.

All the answers are to be recorded on the Answer Sheet. Return only the answer sheet to the person named on the answer sheet. Please record all answers by circling the number on the answer sheet corresponding to the number you choose for the answer to each question.

Study Processes

Your answers to this questionnaire refer to your study attitudes and processes. For each item there is a 5-point scale written in the Answer Sheet.

5 : this item is **always** or **almost always** true of me

4 : this item is **frequently** true of me

3 : this item is true of me about **half the time**

2 : this item is **sometimes** true of me

1 : this item is **never** or **only rarely** true of me

Circle the number on the answer sheet that best fits your **immediate** reaction. Do not spend a long time on each item: your first reaction is probably the best one. Please answer each item.

Do not worry about projecting a good image. Your answers are **CONFIDENTIAL.**

Thank you again for your cooperation.

Reference

Biggs J. 1987. The Study Process Questionnaire (SPQ) : Manual. Hawthorn, Vic.: Australian Council for Educational Research.

1. I chose my present courses largely with a view to the job situation when I graduate rather than out of their intrinsic interest to me.

2. I find that at times studying gives me a feeling of deep personal satisfaction.

3. I want top grades in most or all of my courses so that I will be able to select from among the best positions available when I graduate.

4. I think browsing around is a waste of time, so I only study seriously what's given out in class or in the course outlines.

5. While I am studying, I often think of real life situations to which the material that I am learning would be useful.

6. I summarize suggested readings and include these as part of my notes on a topic.

7. I am discouraged by a poor mark on a test and worry about how I will do on the next test.

8. While I realise that truth is forever changing as knowledge is increasing, I feel compelled to discover what appears to me to be the truth at this time.

9. I have a strong desire to excel in all my studies.

10. I learn some things by rote, going over and over them until I know them by heart.

11. In reading new material I often find that I'm continually reminded of material I already know and see the latter in a new light.

12. I try to work consistently throughout the term and review regularly when the exams are close.

13. Whether I like it or not, I can see that further education is for me a good way to get a well-paid or secure job.

14. I feel that virtually any topic can be highly interesting once I get into it.

15. I would see myself basically as an ambitious person and want to get to the top, whatever I do.

16. I tend to choose subjects with a lot of factual content rather than theoretical kinds of subjects.

17. I find that I have to do enough work on a topic so that I can form my own point of view before I am satisfied.

18. I try to do all of my assignments as soon as possible after they are given out.

19. Even when I have studied hard for a test, I worry that I may not be able to do well in it.

20. I find that studying academic topics can at times be as exciting as a good novel or movie.

21. If it came to the point, I would be prepared to sacrifice immediate popularity with my fellow students for success in my studies and subsequent career.

22. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.

23. I try to relate what I have learned in one subject to that in another.

24. After a lecture or lab I reread my notes to make sure they are legible and that I understand them.

25. Lecturers shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.

26. I usually become increasingly absorbed in my work the more I do.

27. One of the most important considerations in choosing a course is whether or not I will be able to get top marks in it.

28. I learn best from lecturers who work from carefully prepared notes and outline major points neatly on the blackboard.

29. I find most new topics interesting and often spend extra time trying to obtain more information about them.

30. I test myself on important topics until I understand them completely.

31. I almost resent having to spend a further three or four years studying after leaving school, but feel that the end results will make it all worthwhile.

32. I believe strongly that my main aim in life is to discover my own philosophy and belief system and to act strictly in accordance with it.

33. I see getting high grades as a kind of competitive game, and I play it to win.

34. I find it best to accept the statements and ideas of my lecturers and question them only under special circumstances.

35. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.

36. I make a point of looking at most of the suggested readings that go with the lectures.

37. I am at college/university mainly because I feel that I will be able to obtain a better job if I have a tertiary qualification.

38. My studies have changed my views about such things as politics, my religion, and my philosophy of life.

39. I believe that society is based on competition and schools and universities should reflect this.

40. I am very aware that lecturers know a lot more than I do and so I concentrate on what they say is important rather than rely on my own judgement.

41. I try to relate new material, as I am reading it, to what I already know on that topic.

42. I keep neat, well-organized notes for most subjects.

STUDY PROCESS QUESTIONNAIRE : FORM UC

ANSWER SHEET

(Please remove from main Questionnaire)

Question	Always True	Frequently True	True ½ Time	Sometimes True	Never True	Question	Always True	Frequently True	True ½ Time	Sometimes True	Never True	Question	Always True	Frequently True	True ½ Time	Sometimes True	Never True
1.	5	4	3	2	1	2.	5	4	3	2	1	3.	5	4	3	2	1
4.	5	4	3	2	1	5.	5	4	3	2	1	6.	5	4	3	2	1
7.	5	4	3	2	1	8.	5	4	3	2	1	9.	5	4	3	2	1
10.	5	4	3	2	1	11.	5	4	3	2	1	12.	5	4	3	2	1
13.	5	4	3	2	1	14.	5	4	3	2	1	15.	5	4	3	2	1
16.	5	4	3	2	1	17.	5	4	3	2	1	18.	5	4	3	2	1
19.	5	4	3	2	1	20.	5	4	3	2	1	21.	5	4	3	2	1
22.	5	4	3	2	1	23.	5	4	3	2	1	24.	5	4	3	2	1
25.	5	4	3	2	1	26.	5	4	3	2	1	27.	5	4	3	2	1
28.	5	4	3	2	1	29.	5	4	3	2	1	30.	5	4	3	2	1
31.	5	4	3	2	1	32.	5	4	3	2	1	33.	5	4	3	2	1
34.	5	4	3	2	1	35.	5	4	3	2	1	36.	5	4	3	2	1
37.	5	4	3	2	1	38.	5	4	3	2	1	39.	5	4	3	2	1
40.	5	4	3	2	1	41.	5	4	3	2	1	42.	5	4	3	2	1

NAME ....

COURSE .... YEAR ...

DATE ....

Please return to **M J Swannell**, Maudslay Building

Learning styles questionnaire - forty questions

This questionnaire is designed to find out your preferred learning style(s). Over the years you have probably developed learning "habits" that help you benefit more from some experiences than from others. Since you are probably unaware of this, this questionnaire will help you pinpoint your learning preferences so that you are in a better position to select learning experiences that suit your style.

There is no time limit to this questionnaire. It will probably take you 10-15 minutes. The accuracy of the results depends on how honest you can be. There are no right or wrong answers. If you agree more than you disagree with a statement put a tick by it (✓). If you disagree more than you agree put a cross by it (X). Be sure to mark each item with either a tick or cross.

1 I often take reasonable risks, if I feel it justified. ( )

2 I tend to solve problems using a step-by-step approach, avoiding any fanciful ideas. ( )

3 I have a reputation for having a no-nonsense direct style. ( )

4 I often find that actions based on feelings are as sound as those based on careful thought and analysis. ( )

5 The key factor in judging a proposed idea or solution is whether it works in practice or not. ( )

6 When I hear about a new idea or approach I like to start working out how to apply it in practice as soon as possible. ( )

7 I like to follow a self-disciplined approach, establish clear routines and logical thinking patterns. ( )

8 I take pride in doing a thorough, methodical job. ( )

9 I get on best with logical, analytical people and less well with spontaneous "irrational" people. ( )

10 I take care over the interpretation of data available to me, and avoid jumping to conclusions. ( )

11 I like to reach a decision carefully after weighing up many alternatives. ( )

12 I'm attracted more to new, unusual ideas than to practical ones. ( )

13 I dislike situations that I cannot fit into a coherent pattern. ( )

14 I like to relate my actions to a general principle. ( )

15 In meetings I have a reputation of going straight to the point, no matter what others feel. ( )

16 I prefer to have as many sources of information as possible - the more data to consider the better. ( )

17 Flippant people who don't take things seriously enough usually irritate me. ( )

18 I prefer to respond to events on a spontaneous, flexible basis rather than plan things out in advance. ( )

19 I dislike very much having to present my conclusions under the time pressure of tight deadlines, when I could have spent more time thinking about the problem. ( )

20 I usually judge other people's ideas principally on their practical merits. ( )

21 I often get irritated by people who want to rush headlong into things. ( )

22 The present is much more important than thinking about the past or future. ( )

23 I think that decisions based on a thorough analysis of all the information are sounder than those based on intuition. ( )

24 In meetings I enjoy contributing ideas to the group, just as they occur to me. ( )

25 On balance I tend to talk more than I should, and ought to develop my listening skills. ( )

26 In meetings I get very impatient with people who lose sight of the objectives. ( )

27 I enjoy communicating my ideas and opinions to others. ( )

28 People in meetings should be realistic, keep to the point, and avoid indulging in fancy ideas and speculations. ( )

29 I like to ponder many alternatives before making up my mind. ( )

30 Considering the way my colleagues react in meetings, I reckon on the whole I am more objective and unemotional. ( )

31 At meetings I'm more likely to keep in the background, than to take the lead and do most of the talking. ( )

32 On balance I prefer to do the listening than the talking. ( )

33 Most times I believe the end justifies the means. ( )

34 Reaching the group's objectives and targets, should take precedence over individual feelings and objections. ( )

35 I do whatever seems necessary to get the job done. ( )

36 I quickly get bored with methodical, detailed work. ( )

37 I am keen on exploring the basic assumptions, principles and theories underpinning things and events. ( )

38 I like meetings to be run on methodical lines, sticking to laid-down agendas. ( )

39 I steer clear of subjective or ambiguous topics. ( )

40 I enjoy the drama and excitement of a crisis. ( )

Reference

Honey P and Mumford A, 1986. *The Manual of Learning Styles*

Learning styles questionnaire - scoring

You score one point for each item you ticked (✓). There are no points for items you crossed (X). Simply indicate on the lists below which items were ticked.

	Activist	Reflector	Theorist	Pragmatist
	1	8	2	3
	4	10	7	5
	12	11	9	6
	18	16	13	15
	22	19	14	20
	24	21	17	26
	25	23	30	28
	27	29	37	33
	36	31	38	34
	40	32	39	35
Totals	______	______	______	______

Double the above totals to obtain your learning style score.

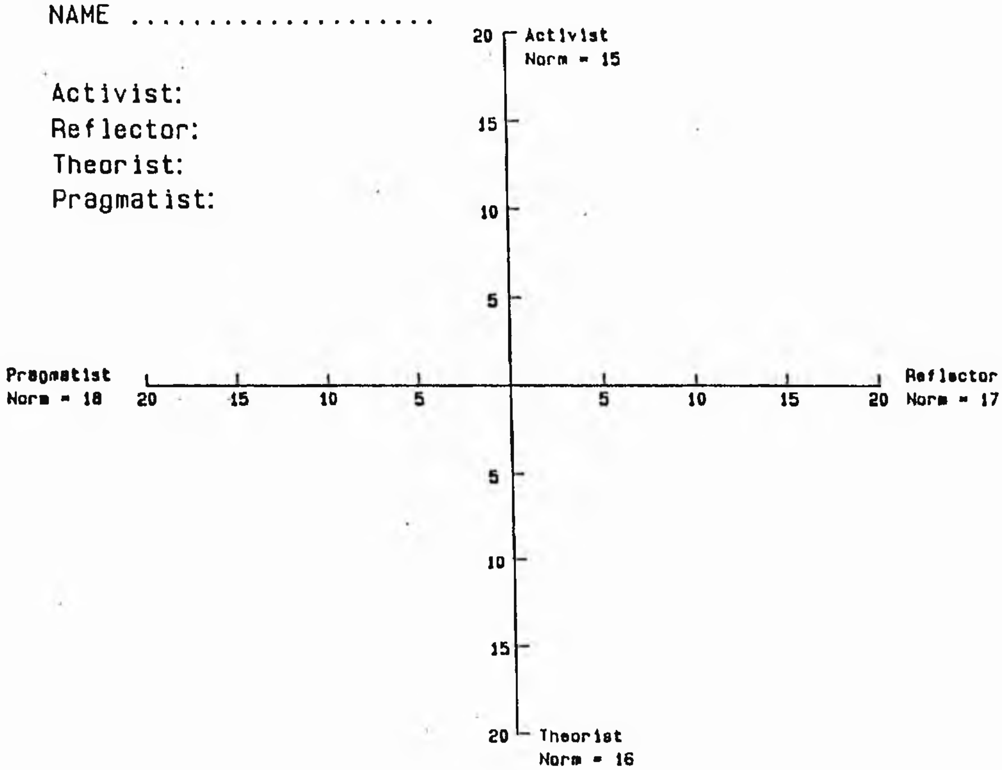
Reference

Honey P and Mumford A, 1986. *The Manual of Learning Styles*.

LEARNING STYLE SCORE

NAME ....

Activist:
Reflector:
Theorist:
Pragmatist:



Activist	Reflector	Theorist	Pragmatist	
20	20	20	20	
19	19	19	19	
18	18	18	18	
17		17	17	Very strong preference
16		16		
15				
14				
13				
12	17	15	16	
	16			Strong preference
11	15	14	15	
10	14	13	14	
9	13	12	13	Moderate preference
8	12	11	12	
7				
6	11	10	11	
5	10	9	10	Low preference
4	9	8	9	
	8		8	
	7	7	7	
	6	6	6	
	5	5	5	
	4	4	4	Very low preference
3	3	3	3	
2	2	2	2	
1	1	1	1	
0	0	0	0	

Appendix 4 - Learning Strategies/Styles and Performance Data

Student codes:

AMT**** MSc Advanced Manufacturing Technology

IECL*** Integrated Engineering course leader

IE***** BEng Honours Integrated Engineering

ME***** BEng Honours Mechanical Engineering

F*** Full time **P***** Part time

2 Year 2 ****001 Student number one

Table A4.1 - Learning strategy scores

SM Surface motive SS Surface strategy

DM Deep motive DS Deep strategy

AM Achieving motive AS Achieving strategy

Student Code	SM	DM	AM	SS	DS	AS
AMTF001	29	22	25	31	22	26
AMTF002	27	29	22	22	28	14
AMTF003	16	28	22	13	27	31
AMTF004	15	27	16	14	25	25
AMTF005	17	14	17	19	17	28
IECL001	20	26	20	18	24	28
IEF2001	23	28	23	20	27	25
IEF2002	15	27	22	18	26	19
IEF2003	18	28	13	14	25	19
IEF2004	21	24	25	25	25	20
IEF2005	31	21	22	29	23	18
IEF2006	16	23	22	13	22	17
IEF2007	31	20	30	30	23	32
IEF2008	17	19	22	16	22	23
IEF2009	19	25	23	21	25	24
IEF2010	28	20	22	26	23	30
IEF2011	19	16	18	19	20	20
IEF2012	23	13	17	22	16	17
IEF2013	9	23	12	16	22	22
IEF2014	32	23	23	28	24	28
IEF2015	25	30	31	19	32	28
IEF2016	16	20	19	19	25	21
IEF2017	13	28	14	12	26	20
IEF2018	23	19	19	24	20	17
IEF2019	17	25	22	15	26	22
IEF2020	16	25	19	14	28	23
IEF2021	14	21	12	13	22	21
IEF2022	29	15	16	24	22	14

Continued on next page

Student Code	SM	DM	AM	SS	DS	AS
IEF2023	28	12	23	27	14	16
IEF2024	32	14	20	28	19	25
IEF2025	22	14	20	21	18	20
IEF2026	23	23	26	22	24	26
IEF2027	18	19	26	19	20	25
IEF2028	27	20	29	27	20	27
IEF2029	22	19	19	20	17	19
IEF2030	22	28	25	19	30	24
IEP2001	27	22	23	25	23	22
IEP2002	25	19	23	21	21	17
IEP2003	24	23	27	23	22	22
IEP2004	20	21	21	20	22	26
IEP2005	21	19	15	22	19	16
IEP2006	28	16	18	27	23	16
IEP2007	24	21	31	22	22	25
IEP2008	16	24	33	15	28	19
IEP2009	16	13	11	16	18	12
IEP2010	14	14	15	15	16	22
IEP2011	31	22	23	26	21	23
MEF2001	28	15	25	27	16	15
MEF2002	28	23	28	25	20	20
MEF2003	27	20	26	30	19	23
MEF2004	15	12	18	13	12	7
MEF2005	28	14	27	24	19	23
MEF2006	21	23	21	21	29	26
MEF2007	16	21	20	19	22	16
MEF2008	16	23	22	22	19	17
MEF2009	28	22	24	23	23	19
MEF2010	28	23	19	27	20	19
MEF2011	28	23	23	23	17	15
MEF2012	22	20	27	21	22	16
MEF2013	32	15	25	25	12	23
MEF2014	31	19	20	29	16	28
MEF2015	17	20	25	17	21	22
MEF2016	22	25	26	23	23	23
MEF2017	17	15	28	18	17	19
MEF2018	24	18	25	23	23	27
MEF2019	19	24	22	16	23	23
MEF2020	30	14	19	24	17	24
MEF2021	27	20	19	29	29	29
MEF2022	18	21	23	17	22	14
MEF2023	16	22	22	19	21	18
MEF2024	29	19	28	27	17	18
MEF2025	27	22	20	27	23	19
MEF2026	25	14	19	22	16	19
MEF2027	15	21	15	17	23	15
MEF2028	15	18	28	15	18	16
MEF2029	24	19	27	27	21	20
MEF2030	24	17	22	23	19	18

Continued on next page

Student Code	SM	DM	AM	SS	DS	AS
MEF2031	22	28	24	20	24	20
MEF2032	32	21	19	25	22	24
MEF2033	30	14	22	30	14	20
MEF2034	20	19	21	20	20	16
MEF2035	18	20	20	17	18	18
MEF2036	21	20	15	22	22	14
MEF2037	21	19	24	28	15	24
MEF2038	28	13	23	22	15	20
MEF2039	29	16	21	30	16	27
MEF2040	18	14	18	13	26	26
MEF2041	25	21	15	27	19	11
MEF2042	19	22	18	11	20	11
MEF2043	24	12	27	25	17	21
MEF2044	27	21	21	23	16	20
MEF2045	25	22	24	21	22	16
MEF2046	15	25	21	21	22	18
MEF2047	26	22	16	16	18	19
MEF2048	18	23	27	19	27	18
MEF2049	22	21	26	23	21	20
MEF2050	27	17	27	22	16	19
MEF2051	23	13	12	16	23	11
MEF2052	25	22	27	23	23	26
MEF2053	23	18	20	22	22	16
MEF2054	27	19	25	20	25	20
MEF2055	14	28	16	13	28	15
MEF2056	28	22	25	23	20	19
MEF2057	21	14	22	22	13	12
MEF2058	28	19	28	30	20	19
MEF2059	15	21	15	19	23	15
MEF2060	31	18	17	29	23	21
MEF2061	20	15	29	21	21	13
MEF2062	29	16	24	27	17	27
MEF2063	23	23	20	16	19	16
MEF2064	29	21	20	28	21	28
MEF2065	27	26	23	23	26	21
MEF2066	26	18	17	20	20	21
MEP3001	21	25	13	19	26	8
MEP3002	22	20	23	20	26	24
MEP3003	13	26	29	10	27	25
MEP3004	13	25	20	15	21	26
MEP3005	20	22	24	23	22	23
MEP3006	31	19	20	23	22	14
MEP3007	24	25	26	22	28	26
MEP3008	17	21	23	21	26	17
MEP3009	29	17	20	22	15	22
MEP3010	22	22	21	16	22	23
MEP3011	22	14	23	26	17	16
MEP3012	26	29	28	23	23	30

Table A4.2 - Learning style scores

Student Code	Activist	Reflector	Theorist	Pragmatist
AMTF001	14	16	14	16
AMTF002	6	12	8	10
AMTF003	4	18	14	18
AMTF004	10	8	14	16
AMTF005	12	12	20	16
IECL001	6	14	20	14
IEF2001	6	20	18	14
IEF2002	10	14	8	10
IEF2003	8	18	10	10
IEF2004	14	14	10	12
IEF2005	12	12	14	12
IEF2006	18	14	10	12
IEF2007	8	20	18	18
IEF2008	8	14	16	14
IEF2009	8	18	14	8
IEF2010	8	20	10	10
IEF2011	12	10	10	4
IEF2012	10	16	6	12
IEF2013	10	14	8	16
IEF2014	10	14	20	14
IEF2015	18	10	14	18
IEF2016	10	12	2	18
IEF2017	12	16	8	10
IEF2018	16	14	12	16
IEF2019	6	8	14	14
IEF2020	14	12	14	12
IEF2021	8	12	10	14
IEF2022	14	10	4	8
IEF2023	6	16	12	10
IEF2024	14	14	8	8
IEF2025	6	20	12	12
IEF2026	8	16	12	16
IEF2027	10	16	8	16
IEF2028	12	14	16	16
IEF2029	10	16	10	10
IEF2030	8	16	16	16
IEP2001	14	4	6	18
IEP2002	14	12	12	14
IEP2003	16	14	16	16
IEP2004	4	12	14	4
IEP2005	4	16	12	14
IEP2006	8	14	12	18
IEP2007	10	16	14	16
IEP2008	10	14	12	16
IEP2009	14	16	10	10
IEP2010	8	14	8	4
IEP2011	12	8	12	8

Continued on next page

Student Code	Activist	Reflector	Theorist	Pragmatist
MEF2001	10	14	12	16
MEF2002	14	16	10	10
MEF2003	12	12	14	16
MEF2004	0	12	12	10
MEF2005	6	18	12	10
MEF2006	8	12	10	14
MEF2007	4	20	14	6
MEF2008	10	16	10	10
MEF2009	18	14	4	16
MEF2010	8	20	16	12
MEF2011	8	12	14	10
MEF2012	16	12	10	14
MEF2013	8	18	16	12
MEF2014	8	18	12	8
MEF2015	6	2	6	8
MEF2016	10	16	16	14
MEF2017	8	12	12	14
MEF2018	14	18	10	14
MEF2019	10	14	14	8
MEF2020	10	10	8	8
MEF2021	12	18	16	18
MEF2022	10	10	12	16
MEF2023	14	12	8	10
MEF2024	16	10	16	12
MEF2025	8	12	12	8
MEF2026	12	18	14	12
MEF2027	10	18	14	12
MEF2028	12	16	14	10
MEF2029	16	12	8	12
MEF2030	8	12	16	10
MEF2031	14	12	12	12
MEF2032	6	12	10	14
MEF2033	14	16	16	16
MEF2034	16	12	8	16
MEF2035	6	14	4	12
MEF2036	14	16	10	6
MEF2037	10	20	10	10
MEF2038	8	20	8	12
MEF2039	12	18	14	14
MEF2040	2	20	20	12
MEF2041	10	14	14	20
MEF2042	12	14	16	14
MEF2043	12	16	14	14
MEF2044	8	18	14	6
MEF2045	8	18	14	10
MEF2046	10	18	6	14
MEF2047	12	20	12	8
MEF2048	8	10	12	14
MEF2049	12	20	20	14

Continued on next page

Student Code	Activist	Reflector	Theorist	Pragmatist
MEF2050	4	16	16	16
MEF2051	14	16	16	12
MEF2052	6	18	12	18
MEF2053	12	14	8	6
MEF2054	12	20	10	10
MEF2055	10	4	4	12
MEF2056	18	12	8	14
MEF2057	8	16	12	10
MEF2058	10	20	14	14
MEF2059	8	18	14	6
MEF2060	12	20	12	8
MEF2061	16	16	10	12
MEF2062	16	10	16	14
MEF2063	16	10	6	10
MEF2064	12	10	8	16
MEF2065	8	16	10	8
MEF2066	9	14	12	12
MEP3001	8	16	14	18
MEP3002	14	14	12	14
MEP3003	12	16	12	14
MEP3004	8	16	14	2
MEP3005	8	12	10	12
MEP3006	6	16	20	14
MEP3007	10	16	14	12
MEP3008	12	18	10	16
MEP3009	6	12	10	10
MEP3010	4	10	16	6
MEP3011	6	12	8	16
MEP3012	12	12	12	14

Table A4.3 - Student assessed marks (per cent)

Student Code	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
AMTF001	--	69	67	70	62
AMTF002	--	63	31	49	43
AMTF003	--	76	65	79	65
AMTF004	--	75	67	84	68
AMTF005	--	71	73	77	67
IECL001	--	--	--	--	--
IEF2001	44	69	51	60	52
IEF2002	23	17	6	52	15
IEF2003	43	61	40	10	45
IEF2004	48	63	53	43	53
IEF2005	47	71	63	75	58
IEF2006	44	51	48	46	47
IEF2007	37	63	47	35	46
IEF2008	40	65	45	51	47
IEF2009	34	55	51	48	45
IEF2010	42	72	61	48	56
IEF2011	53	64	60	61	58
IEF2012	33	50	47	30	42
IEF2013	46	65	54	51	53
IEF2014	79	68	68	82	72
IEF2015	48	61	60	61	55
IEF2016	44	54	49	54	48
IEF2017	42	32	53	50	44
IEF2018	41	60	43	52	45
IEF2019	46	72	59	58	56
IEF2020	56	64	57	60	58
IEF2021	44	65	48	58	50
IEF2022	56	67	61	82	60
IEF2023	47	66	60	83	56
IEF2024	86	77	67	75	77
IEF2025	52	66	60	53	58
IEF2026	33	67	65	74	52
IEF2027	49	54	60	66	54
IEF2028	67	62	63	72	64
IEF2029	42	57	61	70	53
IEF2030	57	59	58	64	58
IEP2001	45	56	60	50	52
IEP2002	57	64	59	60	60
IEP2003	57	74	69	70	65
IEP2004	71	78	63	64	70
IEP2005	53	62	33	45	50
IEP2006	62	74	66	63	67
IEP2007	70	74	72	77	71
IEP2008	48	61	62	76	56
IEP2009	52	35	56	45	48
IEP2010	54	63	71	77	62
IEP2011	47	42	69	80	52

Continued on next page

Student Code	Examination	Continuous Assessment	Design Project	CAD	Aggregate
MEF2001	47	65	73	60	53
MEF2002	64	74	71	70	67
MEF2003	66	66	67	63	66
MEF2004	58	68	53	68	60
MEF2005	42	66	61	65	48
MEF2006	39	68	59	60	47
MEF2007	66	67	75	75	67
MEF2008	39	56	47	60	43
MEF2009	38	56	69	68	45
MEF2010	38	59	63	58	45
MEF2011	54	66	66	58	58
MEF2012	56	50	66	58	56
MEF2013	37	59	64	70	44
MEF2014	47	65	73	65	53
MEF2015	77	58	67	65	72
MEF2016	54	72	67	65	59
MEF2017	39	66	64	70	47
MEF2018	43	63	64	55	49
MEF2019	49	75	63	68	55
MEF2020	34	60	69	68	42
MEF2021	48	57	66	68	52
MEF2022	48	71	74	80	55
MEF2023	34	47	75	73	41
MEF2024	58	75	69	68	63
MEF2025	62	76	71	68	66
MEF2026	61	71	73	65	64
MEF2027	66	64	68	65	65
MEF2028	57	63	63	65	59
MEF2029	58	69	67	65	61
MEF2030	56	70	67	65	60
MEF2031	45	72	57	80	51
MEF2032	55	64	74	68	59
MEF2033	77	75	70	65	76
MEF2034	45	57	68	68	50
MEF2035	39	63	64	70	46
MEF2036	49	69	60	60	54
MEF2037	57	51	63	68	56
MEF2038	37	67	68	60	46
MEF2039	49	68	54	60	53
MEF2040	55	63	55	58	57
MEF2041	66	67	58	66	65
MEF2042	46	64	73	65	52
MEF2043	48	68	64	70	53
MEF2044	63	76	56	65	65
MEF2045	48	61	73	65	53
MEF2046	58	65	66	68	60
MEF2047	71	68	73	68	71
MEF2048	43	56	70	55	48
MEF2049	63	61	64	68	63

Continued on next page

Student Code	Examin-ation	Continuous Assessment	Design Project	CAD	Aggregate
MEF2050	60	76	77	80	65
MEF2051	56	76	74	80	62
MEF2052	58	58	63	60	59
MEF2053	50	50	60	60	51
MEF2054	53	64	66	65	56
MEF2055	56	58	53	65	56
MEF2056	39	51	72	60	45
MEF2057	46	29	57	55	44
MEF2058	41	58	49	55	45
MEF2059	58	64	61	65	60
MEF2060	51	63	55	60	54
MEF2061	47	64	65	63	52
MEF2062	66	68	60	60	66
MEF2063	37	53	70	68	44
MEF2064	40	56	62	65	45
MEF2065	40	69	71	78	49
MEF2066	38	59	62	65	45
MEP3001	65	73	77	77	68
MEP3002	70	75	78	76	72
MEP3003	38	73	72	74	49
MEP3004	62	80	65	75	65
MEP3005	58	72	76	76	63
MEP3006	45	76	76	78	55
MEP3007	50	76	77	79	59
MEP3008	46	77	72	77	56
MEP3009	29	76	80	81	45
MEP3010	77	73	79	78	77
MEP3011	51	69	68	71	57
MEP3012	46	78	68	75	55

Department of Mechanical and Marine Engineering

Student Workload Project

Student Logbook

Course: Higher Diploma in Mechanical Engineering

Week Starting: ....

Name: ....

Student Number: ....

To the Student

Thank you for taking part in this important investigation of student workload in the Higher Diploma in Mechanical Engineering.

This booklet is your logbook, in which you will record your activities during one week. As well, for most days there is a series of short questions for you to answer, concerning specific aspects of your studies.

We ask you to fill in the pages accurately, and with as much detail as possible of your study habits. This will provide us with valuable information which will help us to improve the course, both for you and for future students.

On the opposite page we have provided a sample of what a one-day journal entry might look like. Note that your activities include non-academic items, such as sports, eating and clubs, though not as much detail of these is required.

Please note that the information that you provide is confidential. It will not be shown to staff outside the research team. This is definitely not an attempt to find out who is working hard and who isn't!

Finally, if you have any questions regarding this logbook, please contact either of us. Once again, thank you for helping us with the project.

Mike Pomfret
Room FG606
Ext. 6647

Eric Wong
Room FG635
Ext. 6659

Sample Page

Time	Subject/Topic	Activity
Before 8:30 am	Woke late - no time for breakfast - had to leave home at 7:30 to get to lecture. Was a few minutes late, but so was everyone else.	
8:30 - 9:30 am	Mech. Technology	Lecture on gear cutting - given 4 sides of handouts Lecturer went too fast - difficult to understand.
9:30 - 10:30	Mech. Technology	as above - finished with some exercises which helped my understanding.
10:30 - 11:30	Go to canteen for drink & finish maths assignment	
11:30 - 12:30 pm	Communication	exercises on writing reports - helpful and fun!
12:30 - 1:30	Lunch with friends, then play cards.	
1:30 - 2:30	EE Technology	Lab. work on use of condensers - followed instructions on lab. sheet.
2:30 - 3:30	EE Technology	Lab. work continued - finished early, so started writing up report
3:30 - 4:30	Mathematics	Tutorial - handed in assignment - did exercises on polynomial approximation of curves.
4:30 - 5:30	Mathematics	More exercises - easy, just putting numbers into equations. Finished early as everyone tired and fed up.
5:30 - 6:30	Went to library to finish writing up experiment. Also found good book for Mech. Technology.	
6:30 - 7:30	Went to Hung Hom with girlfriend for dinner and walk round market.	
7:30 - 8:30	Travelling home, then start on Fluid Mechanics work - big assignment due in two days - just starting.	
8:30 - 9:30	Still trying to work out assignment - phone friend for help - now making progress.	
9:30 - 10:30	Watch TV with family (parents and two brothers).	
After 10:30 pm	More TV - movie finished about 11:30	

Day: Monday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Laboratory work

1. Describe what you did in the laboratory today.

2. How long did it take you to do the experiment?

3. How long did it take you to write up the experiment:
   a) in the laboratory?

   b) elsewhere (library, home, etc)?

4. What did you learn from the experiment?

Day: Tuesday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Lectures

1. How many hours of lectures did you have today?

2. How many pages of handouts were there for today's lectures?

3. How many pages of notes did you take in today's lectures?

4. When will you read/study the notes you took in the lectures today?

5. How do you use your lecture notes and text books to revise for tests?

Day: Wednesday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Library

1. Did you go to the library today?

2. If so, how long, in total, did you spend there?

3. What did you do while you were in the library?

4. What books/journals did you look at?

Day: Thursday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Tutorials*

1. How many hours of tutorials did you have today?

2. What did you do to prepare for the tutorials?

3. What did you do in the tutorials?

4. Have you been set work to complete for the next tutorials?

* Tutorials may include parts of lectures, during which there has been a problem solving session or some group work.

Day: Friday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Reading and Revision

1. Have you done any general revision this week? If yes, what did you do and how long did it take?

2. How do you normally revise a subject?

3. When reading a textbook, how do you learn from it (make notes, try exercises, photocopy pages, etc.)?

4. Do you normally revise alone, or with your friends? If with your friends, how do you work together?

Day: Saturday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Day: Sunday

Time	Subject/Topic	Activity
Before 8:30 am		
8:30 - 9:30 am		
9:30 - 10:30		
10:30 - 11:30		
11:30 - 12:30 pm		
12:30 - 1:30		
1:30 - 2:30		
2:30 - 3:30		
3:30 - 4:30		
4:30 - 5:30		
5:30 - 6:30		
6:30 - 7:30		
7:30 - 8:30		
8:30 - 9:30		
9:30 - 10:30		
After 10:30 pm		

Assignments/Tests

1. How much time have you spent this week revising for tests?

2. In the table below, list the assignments you had to complete this week. For each of them, show the topic, time spent, its nature (essay, set of problems, project outline, etc) and the degree of difficulty (circle your choice).

Topic	Time	Nature	Difficulty
			easy/average/hard
			easy/average/hard
			easy/average/hard
			easy/average/hard
			easy/average/hard

Appendix 6 - Published Papers and Conferences

Button B L, Jeffery G B S and Swannell M J. 1990. Engineering the course, *Engineering Design Education and Training,* Spring 1990, 8-11.

Button B L and Swannell M J. 1987. Helping students to manage their own learning - the start of an expert system. *Nordic Conference on Computer Aided Instruction,* Stockholm, Sweden, 2-5 June 1987, 129-43.

Button B L and Swannell M J. 1990. A proposal to evaluate learning strategies and styles in engineering design education. *Annual Conference of the European Society of Engineering Education (SEFI), Design in Engineering Education,* Dublin, 4-7 September 1990, 51-5.

Jeffery G S B and Swannell M J. 1991. Project assessment in the BEng Honours Integrated Engineering degree course at Nottingham Polytechnic. *SEED 91 Conference (Sharing Experience in Engineering Design), Student Assessment,* 24-5 June 1991, 40-7.

Swannell M J. 1989. Course overview of BEng Honours Integrated Engineering degree, course philosophy and rationale. *International Conference, The Tertiary Education in Europe and the Greek Case,* Patras, Greece, 18-20 September 1989.

Swannell M J and Button B L. 1991. Engineering student learning strategies and styles: initial results. *Twelfth Educational Computing Organisation of Ontario and the Eighth International Conference on Technology and Education Joint Conference,* Toronto, Canada, 3-10 May 1991, 798-800.

ENGINEERING THE COURSE

Bryan Button, Gordon Jeffery and Malcolm Swannell describe the origin of Nottingham Polytechnic's new BEng Honours integrated engineering course - its aims rationale, structure, curriculum and benefits, together with the associated bidding, design, validation and accreditation processes.

The process of setting up a new engineering course at Nottingham Polytechnic (formerly Trent) has taken just one year. Some 60 students have already enrolled on the sandwich and part-time modes of the course, and the course has received significant financial support from industry and Government.

The course is based on the Engineering Council's 1988 consultative document *An Integrated Engineering Degree Programme*, which was a direct response to the needs of industry. If engineering is thought of as a discipline the intergrated engineering is an approach in which the sub-disciplinary boundaries, which traditionally divide the engineering profession, are diffused and ignored.

Polytechnics and universities were invited to bid for additional funds to develop and integrated engineering degree programme by responding to the Engineering Council document. Of some 30 institutions which applied six were selected and awarded funds from the Department of Trade and Industry in May 1989. Nottingham started its course in September.

Nottingham's integrated engineering degree provides:

- ☐ a broad academic foundation for the chartered engineer, reflecting the needs of many careers in engineering and in contrast to most engineering degree courses which are specialised.
- ☐ access to the engineering profession to those who may not have studied physics. It is necessary to increase the number of engineering students and this is made more difficult by the demographic downturn. Removing the requirement for physics to have been studied at 'A' level will double the number of students who are eligible to study engineering and most importantly will substantially increase the number of potential women students.
- ☐ a balanced curriculum that combines the subjects that engineers use most often and is directed towards the fulfillment of the needs of the majority of engineers.

THE COURSE

Details of the planning, research, policy, rationale, aims and syllabus are decribed below.

DESIGN CONSIDERATIONS

An opportunity was provided to design a course free of existing curricula, based on the design approach and actions suggested by Bryan Button in his 1985 report *Learning Methods for Engineering Courses*.

AIMS

The aims of the course are to:

- ☐ provide a broad foundation for career development
- ☐ emphasise the interdisciplinary nature of engineering
- ☐ create a good learning environment
- ☐ increase access to engineering

RATIONALE

To achieve these aims the curriculum should embody the following:

- ☐ integrate several engineering disciplines
- ☐ make the content relevant and exciting
- ☐ use Engineering Design, Computing and the Engineering Dimension as integrating themes throughout
- ☐ use student-centred learning
- ☐ provide credit accumulation and transfer with other home and overseas institutions
- ☐ have an appropriate assessment policy
- ☐ embody a European and international dimension

PROJECT BASED LEARNING

Project-based learning which supports student-centred learning has adopted throughout the course and is entirely appropriate to the concept of integrated engineering. Projects have been designed to cross the boundaries of all disciplines.

Group projects have already involved students in team-building activities, at an outdoor studies centre. This spring 12 lecturers and technicians plan to visit Aalburg Universitescenter in Denmark, to observe their a project-based engineering degree course.

COURSE DEVELOPMENTS

Nottingham Polytechnic was keen to participate in the Integrated Engineering Degree Programme. The Faculty of Engineering is ideally placed to offer an integrated Engineering degree because: degree courses are offered in the main engineering disciplines of civil, electrical and electronic, manufacturing and mechanical engineering. There is also experience of offering multi-disciplinary courses and the computing department is part of the faculty.

Following receipt of the Engineering Council consultative document a multi-disciplinary planning team was established. The team comprised lecturers drawn from the contributing departments – business and management studies, civil engineering, computing, electrical and electronic engineering, industrial and production engineering, mathematics, and mechanical engineering.

A BUSY YEAR

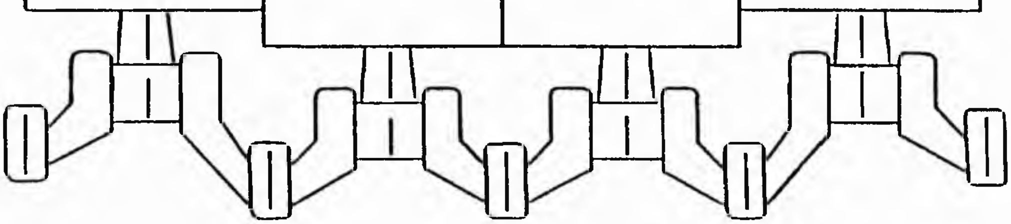
Throughout the 1988-89 academic year the team met formally every week to: prepare the competitive bid; review the consultative document and develope the curriculum; reinforce the integration of teaching staff; prepare the course for validation and accreditation.

It was an unusual and exciting challenge – to design, validate, accredit and market a degree course within one academic year

Course structure-awards, credit, modes and duration

Modes of study

Awards	Credit /unit	Part-time /year	Full-time /year	Sandwich /year
Certificate	30	2	1	
Diploma	30	3	2	3
BEng Degree	30	5	3	4



ACCREDITATION

It was possible to design the course curriculum to meet the accreditation requirements of the Institutions of Mechanical, Electrical, and Production Engineers, and those of the Institution of Civil Engineers except for the geotechnics and surveying sectors.

The polytechnic was visited last October by an accreditation panel which consisted of representatives from the three former institutions – the first time known to us when three institutions have come together to consider a course for accreditation.

INTEGRATION

The concept of integration between subjects was paramount. Integrating themes linking syllabuses were identified and enhanced. The content of the subjects of information engineering and physical and chemical structures, processes and properties was selected to support the engineering core.

COURSE STRUCTURE

From the outset it was decided that full-time, sandwich and part-time modes of attendance would be available.

The full-time mode requires attendance at the polytechnic for three successive years. The sandwich mode is of the thick sandwich type. Students attend the polytechnic for two years, spend the third year in an industrial placement and return to the polytechnic for their final year's study. The part-time mode requires the student to attend the polytechnic for one day and evening each week for five years. There is some integration with the sandwich course students.

CURRICULUM

As a start point, the structure and curriculum proposed in the Engineering Council consultative document were accepted. Each of the subject syllabuses was considered by a specialist and altered as necessary. It was then considered by the entire planning team and modified to enhance integration and to ensure consistency with other units.

ASSESSMENT

A simple policy has been adopted whereby the amount of time allocated to each subject is directly proportional to the number of credits awarded and to how the marks are allocated. This means that the students are rewarded fairly for what they are required to do to meet the aims of the course. The quality of their responses will determine the proportion of the allocated marks they are awarded.

An innovation is to be able to recognise success at progressive stages throughout the course by the award of a certificate or diploma where appropriate.

Methods of assessment were strongly debated and it was decided that only the engineering core subjects should be tested with written examinations at the end of each academic year. It was agreed that the other subjects could be more effectively and appropriately assessed by using continuous assessment.

UNITISATION

The course has been designed using a unitised structure. This will help promote student mobility and access throughout the UK and other member states in the European Community.

A EUROPEAN DIMENSION

As part of the Engineering Dimension, the course has started by offering students the opportunity to study a foreign language and its country's culture – on a voluntary basis and extra to the curriculum. Many lecturers and support staff have joined the students in

Course structure-subjects, credit, level and assessment

Subjects	Credit /unit	Level I	Level II	Level III	Type of assessment
Engineering core	31	•	•	•	End test
Information Engineering	7	•	•		Continuous
Physical and Chemical Structures, Processes and Properties	4	•			Continuous
Enterprise, Organisation and People	7	•	•	•	Continuous
Integrating Studies	41	•	•	•	Continuous
	90				

timetabled classes in French, German, Italian, Spanish and Mandarin. One of the aims of these classes is to equip students with a language proficiency so that they can undertake their industrial placement abroad.

In the second year of the course further language study may be offered, again on a voluntary basis, but substituted for part of the curriculum and not counting the assessment towards progression. The final-year students will have the same option but if they choose to take it then the assessment will count towards the final award.

INDUSTRIAL SUPPORT

Industry, in addition to confirming its support for the concept of integrated engineering (by responding to questionaires, attending a seminar and a validation meeting), has donated over £250,000 to help with the course development. This is in addition to the £70,000 from the DTI.

British Petroleum has given the largest cash donation – £110,000. The contributions from 13 other companies are mainly in the form of student sponsorships and the provision of industrial lecturers, industrial members of the course advisory committee and industrial project supervisors. Such support will ensure the continuous involvement with industry in the development of the course, and will help ensure its success.

BENEFITS OF THE COURSE

The benefits of this course are:

- ☐ students are able to keep their career options open and will be better equipped to adapt to changes throughout their career
- ☐ the course will provide an excellent education that will fit students not only to become engineers, but to apply for about 35 per cent of jobs advertised to graduates of all disciplines
- ☐ being a new course the opportunity has been taken to reassess the development of new learning material
- ☐ the students graduate with a much broader competence
- ☐ the course offers multiple routes by which the graduate may obtain chartered status
- ☐ the support of industry has enhanced resources.

MARKETING AND RECRUITMENT

Marketing the course posed particular problems since it was not possible to offer any places to students before the course was validated in May 1989. The course was marketed by: carrying out a number of careers-related promotions in schools; holding seminars for careers advisers and school teachers – these were well attended and provided a useful forum for the exchange of views, most of which were favourable to the aims of the integrated engineering course; linking with ACCESS and HITECC courses which provide a source of students; and taking advertisments in the press.

However, the number of women students recruited remains disproportionately small. We are determined to increase the number of women engineering students and part of our marketing activities during the current session will be directed to this purpose.

FUTURE DEVELOPMENTS

Additional learning material is being developed, particularly for integrating projects. It is planned to set up a unit to do this.

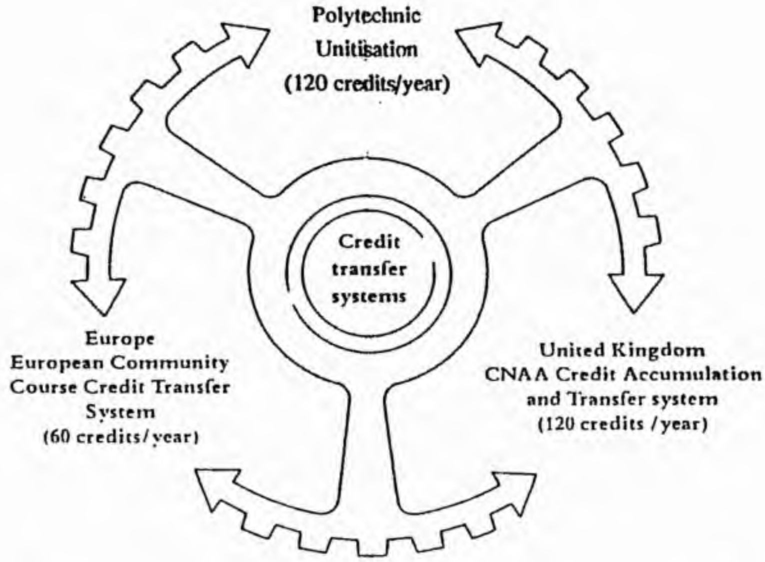
Accreditation will be sought from the Engineering Council for incorporated status for the certificate and diploma qualifications that may be awarded following the successful completion of each year of the course.

A study will be undertaken to determine the minimum prerequisites for admission of students to the course. This information will be fed back to assist in the design of suitable access courses.

As the integrated engineering course develops it will bring about further integration within the faculty and the erosion of departmental boundaries, in a way that is consistent with the requirements of modern engineering.

The units of other engineering courses will become subsumed, where appropriate, within the Integrated Engineering course curricula.

And, finally, the feasibility of developing links with universities abroad will continue to be explored.



OVERVIEW OF THE CONTENT OF THE MAIN SUBJECTS

ENGINEERING CORE
Engineering Mechanics
Applied Thermodynamics
Mechanics of Fluids
Mechanics of Machines
Electrical and electronic engineering
Electro-Technology
Electrical Networks
Electronic Engineering Electrical Powers
Analogue Electronics
Digital Electronics and Computer Architecture
Control and Instrumentation
Power Electronics
Electrical Drives
Electrical Power Systems
Materials and strength of materials
Materials Engineering
Stress and Displacement Analysis
Advanced Materials Technology
Manufacturing engineering
Manufacturing Processes
Introduction to Manufacturing Systems
Development of Manufacturing Systems
Advanced Manufacturing Systems
Advanced Manufacturing Technology
INFORMATION ENGINEERING
Linear and Nonlinear Systems
Discrete and Continuous Variable Systems
Computing - Programming and Graphics
Models, Modelling and Problem Solving
Contemporary Methods for Curves, Expansions and Optimization
Information Systems and Further Differential Equations
Applied Statistics, Modelling and Simulation

PHYSICAL AND CHEMICAL STRUCTURES, PROCESSES AND PROPERTIES
Structure of Matter
Properties of Matter
Properties of Electromagnetic Waves
The Physics of Electronic Devices

ENTERPRISE, ORGANISATION AND PEOPLE
Enterprise, Skills and Competencies
Communication Skills
Building and Working in Teams
Decision Making Skills and Management Techniques
The Business Environment and Marketing
Finance for Non-Financial Specialists
The Engineer in Society

INTEGRATING STUDIES
Engineering Practice (manufacturing and mechanical)
Engineering Practice (electrical)
Communicating through Engineering Drawing
Introduction to Computer-Aided Drawing
Practical Engineering Laboratory Work
Introduction to Integrated Design Projects
Computer-Aided-Design
Experimental Techniques in Engineering
Use of Computers in Engineering
Design Case Studies
Design of Machine Elements
Electrical/Electronic Design
Integrated Design Projects
Individual Major Study Project
Further Engineering Experimental Techniques
Integrated Design Studies

HELPING STUDENTS TO MANAGE THEIR OWN LEARNING - THE START OF AN EXPERT SYSTEM

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Summary

Computers are only one of many tools that provide an aid to learning and should not be treated as a panacea for all learning. Computers should be integrated into a course and used as one of many resources. The philosophy of educational methodology in conjunction with course design is of overriding importance when considering all forms of learning material including computer aided learning. Computers can only be effective learning tools when integrated into a well designed course that is well organised.

In producing and developing learning material the needs of students must be considered. In particular their past experience and their learning style and strategies should be considered. At Trent Polytechnic an expert system is being developed that gives students the opportunity to determine their existing knowledge of the topic to be studied and to determine their learning style. The expert system will then direct students to suitable learning material and finally they will be able to assess their learning of the topic and if necessary obtain advice on remedial study. The model that is to be developed within this expert system is to be applied to a wide range of learning material.

Introduction

I would emphasise learning and helping students to learn rather than instruction and teaching, in order to highlight that students should have the freedom to learn and take responsibility for their own learning. You will notice that I have changed the title of my talk from "Teaching students..." to "Helping students to manage their own learning." Let us concentrate on learning which is more meaningful than instruction. What John Amos Comenius (1592-1670) (Keatinge, 1896) said three centuries ago is still true today: "To seek and find a method by which teachers teach less and students learn more."

In my talk I would like to take you first through the background which includes the scale of objectives, learning methods, learning systems,

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learning styles and then the experiential learning cycle. Secondly, I will give you an overview of the course structure showing, through four examples, the use of computers at Trent Polytechnic. Finally, I will look at possible ways of using expert systems for the future.

I would recommend Carter's scale of objectives for professional education (Carter, 1984)*) which includes personal qualities, skills and knowledge (Figure 1). Whatever method or medium we use for learning we should start with setting out what we want to do. I would suggest that we address ourselves first in designing our courses to the personal qualities we want them to develop in students to enable them to become autonomous learners. The thing that I would pick out above all others in terms of personal qualities is that we want our students to be confident, we want them to know themselves and we surely want them to be creative.

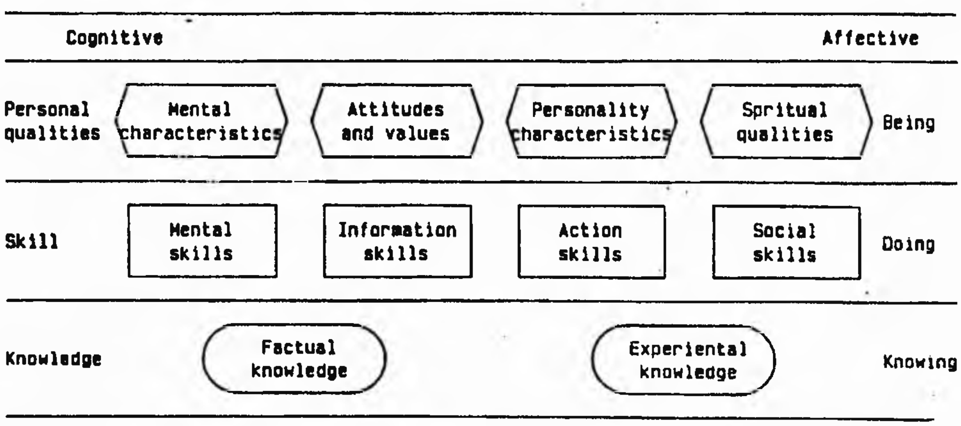

Figure 1: Summary of Taxonomy of Objectives

In terms of skills, what the students need is to acquire communication skills. As they live in a society, they need to be effective communicators to function well in this society. In order to enable them to adapt to changing roles and to keep abreast of increasing technology they need to be autonomous learners, and clearly, they must cooperate both in managing and working with others.

In the area of knowledge, I would single out concepts, rather than facts, because concepts can take you through life. Details we forget. So, if we concentrate on concepts in our learning then students will gain maximum benefits from their learning.

***) References can be found on p. 143.**

Teaching Methods

There are a whole host of teaching methods - audio tapes, books, case studies, computer programs, games, handouts, laboratory work, lectures, proctoring, role-playing, seminars, tape-book, tape-slides, tutorials, video tapes. Let us bear in mind when we use computers they are only one of many resources.

If we have well-designed courseware it does not really matter what method we use. Thermodynamics for example, is considered to be a difficult subject for students. After five years of using a tape-slide framework which had an organised course structure, we carried out a survey in which "over 95 per cent of the students said they enjoyed Thermodynamics, did not find it the most difficult subject and thought the course was well organised" (Button and Dobbins, 1985). I would like to think that all our courseware produced the same student response.

Organisation

There are a number of learning systems we can employ. A traditional one in engineering and science is lectures supported by laboratory work, workshops and tutorials. In Oxford and Cambridge they use a tutorial approach which is supported by lectures, laboratory work and workshops. A resource-based system which originated in America is the Keller plan. In my country again, one-fourteenth of all graduates come from the Open University which employs distance learning. Finally, we should all aim for "open learning", where everyone has access to education and learning, and barriers to learning are removed.

An example of what I consider to be a well-organised course is the course in Thermodynamics mentioned earlier (Figure 2). We start with lectures, which give an overview and create an enthusiasm for what is to come. Then follows the tape-slide presentation, followed by tutorials. The tape-slide programme consists of a pre-test to establish prior knowledge and experience. Then a study of learning using interactive methods followed by a tutorial leading to a post-test. This is supported by a laboratory programme. Further selected lectures are used to consolidate the learning programme. Studens do not move on to something else until they have consolidated the material. Assignments are devised to assess student knowledge and to provide feedback to the students with written reports as well as oral comments.

This learning programme involves other things that are considered to be important, *e.g.* communication skills, inititative, independence and autonomous learning. One example is that students are set an essay in which they are asked to imagine they are a molecule going around a steam plant. A student who was not very good analytically wrote an exciting essay. Given the proper medium the students find it easier to express themselves. I believe we should give our students such opportunities, that is, opportunities to express themselves in other ways.

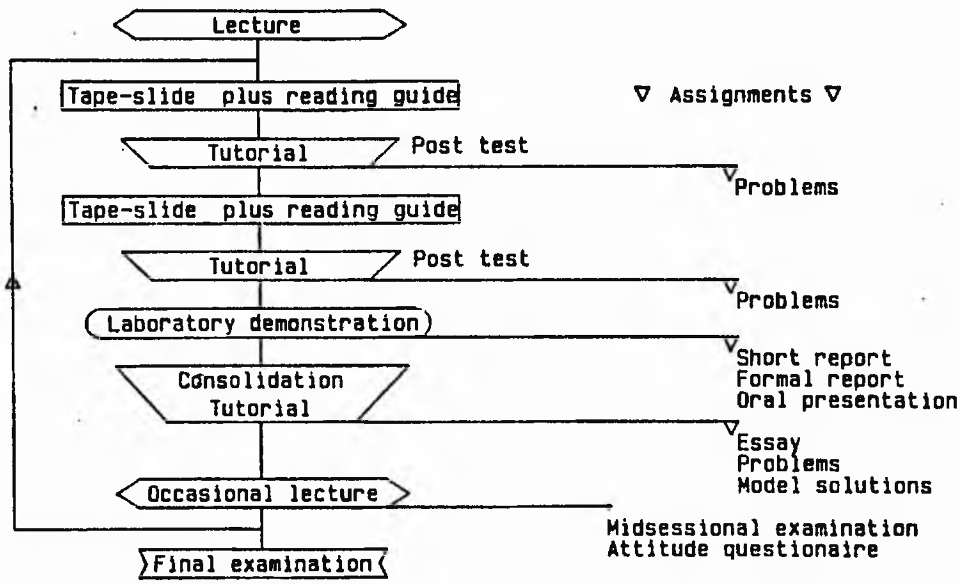

Figure 2: Example of a learning system for Thermodynamics

Examinations still form a major part of assessment within the traditional engineering course. Not only need we to help students to learn the material but we must also help them to pass examinations, which is a skill in its own right.

Learning Styles

We all have our different learning styles and preferences. According to Entwistle (1981), "The existence of widely different learning styles prevents there being any possibility of any single correct way to teach or to learn". If we use one particular style to the exclusion of all others and we try to teach students of a different style, we may not achieve our learning objectives. We need to do something to reinforce existing learning styles whilst developing other learing styles.

People can be classified into four groups according to their learning styles - the Activist, the Reflector, the Theorist and the Pragmatist (McCarthy, 1980/Honey and Mumford, 1986) (see Figure 3). We all have our preferences and we are more comfortable in one area or another according to our preferences. A clever person would, however, make use of all styles of learning.

Now let us look at how we learn. Kolb (1984) defines experiential learning as "the process whereby knowledge is created through the transformation of experience". Using the different learning preferences, we can relate them to the way individuals learn. The activist learns through sensing and feeling; the reflector through watching; the theorist through thinking; and the pragmatist through doing (see Figure 4).

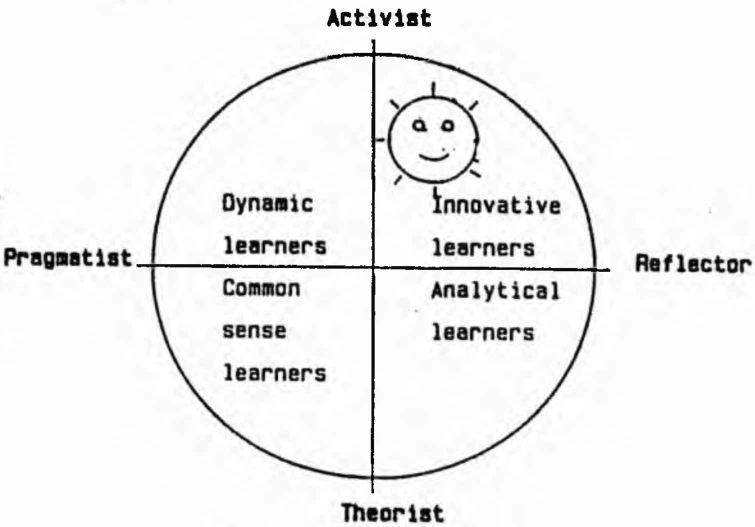

Figure 3: Learning styles

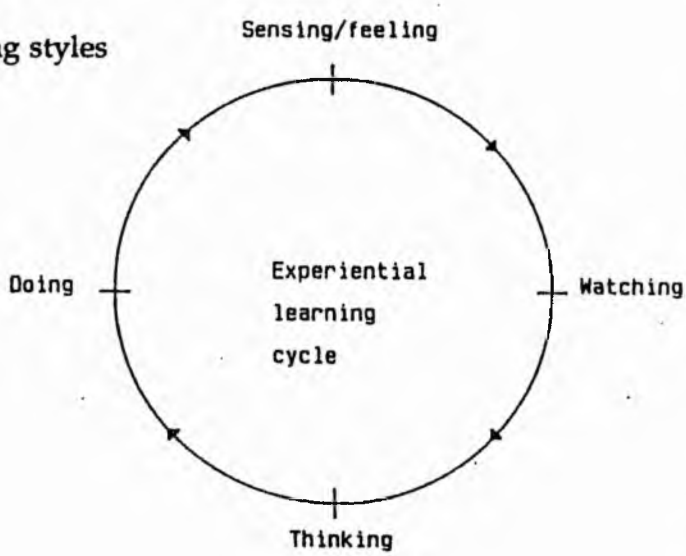

Figure 4: Experiential Learning Cycle

Figure 5 shows the activities associated with the two halves of the brain (McCarthy, 1980). The left half of the brain likes verbal things, likes sequences, sees the trees and is structured while the right half of the brain sees visual-spatial things, likes random patterns, sees the forests, is fluid and spontaneous. Unfortunately, our system tends to suppress free expression. We want people to be more spontaneous, we should put together learning cycles that combine the use of the right and left brain modes and create an experiential learning situation for our students (see Figure 6).

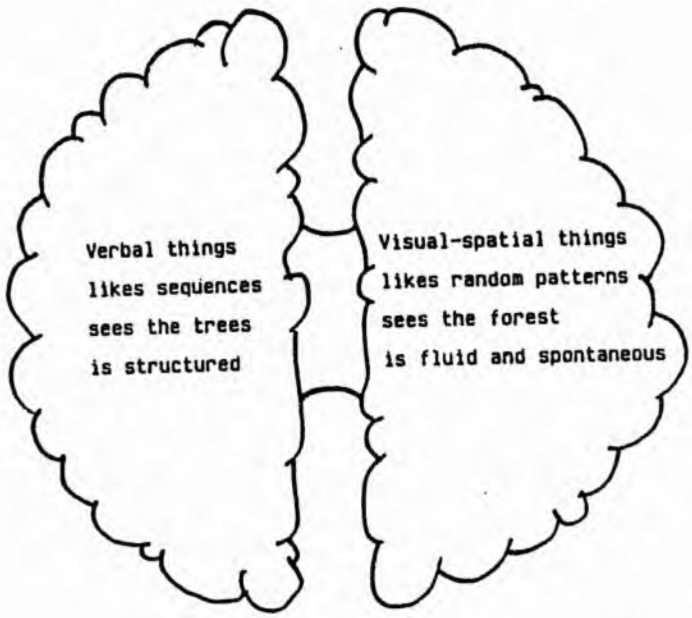

Figure 5: Activities associated with both sides of the brain

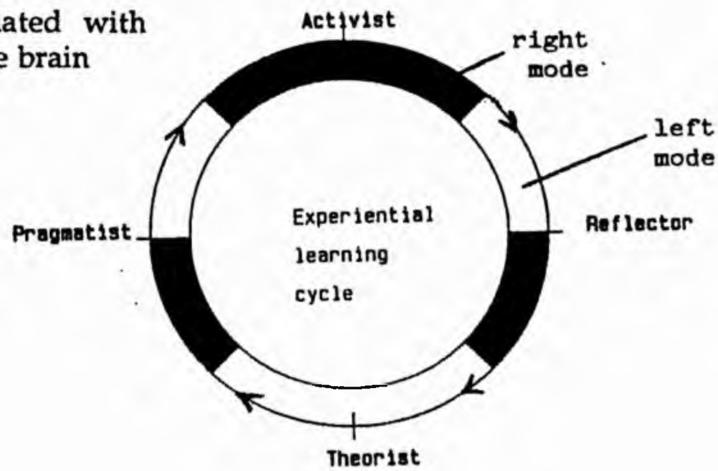

Figure 6: Combining learning cycle and brain mode

Using Computers

At Trent Polytechnic, we a working towards a system whereby students determine their preferred learning style and follow a course of study based on a structure that addresses the aims and objectives of the course, and takes account of the appropriate learning methods suited to the individual. Finally, assessment is used both for student grading by staff and to facilitate remedial work towards mastery of the topic. Throughout we were also conscious of the fact that while the computer is a useful tool in engineering we should really base what we do on educational ideas and not use the computer as the prime method for learning (Figure 7).

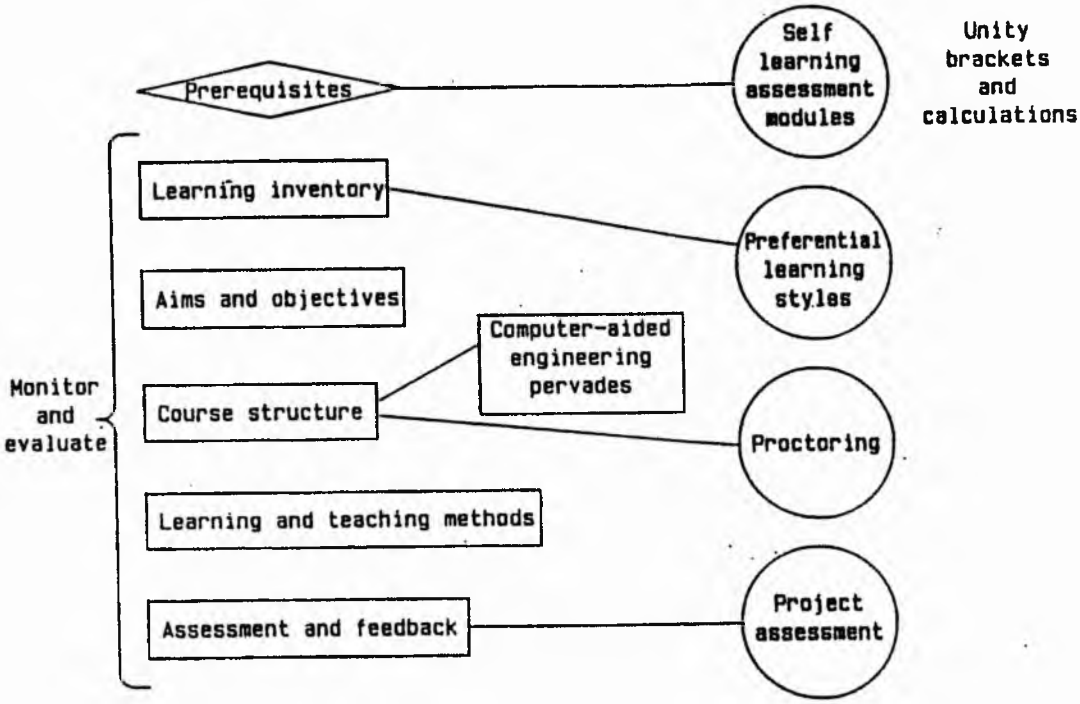

Figure 7: Some features of course design related to computer aided learning

A self-learning assessment module (SLAM) has been developed for the topic of Unity Brackets. This module provides assessment of material that has been self-learnt. The SLAM is based on testing the knowledge of facts, structures, procedures, concepts and principles. There are 48 multiple choice questions in this module examining each part of the content. The student is presented with 12 questions from the database of 48. Troughout the SLAM students are given immediate feedback, either confirming if correct, or when wrong a detailed explanation of the answer is provided. Students are expected to reach a mastery level, which initially has been set at 80 per cent.

The SLAM has been incorporated into an interactive computer program using an authoring language known as MICROTEXT. It is so written that it assesses the students and provides records of student responses as well as giving feedback to the students if the responses are incorrect. If the student has not achieved mastery of the material at the desired level he/she is directed to remedial study before returning to the program for re-assessment. This process is outlined in Figure 8.

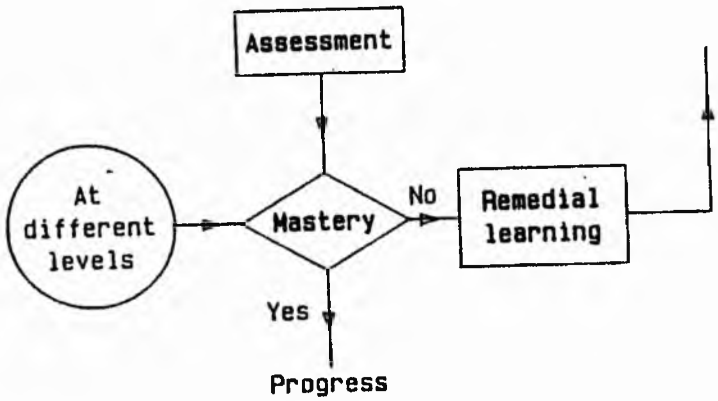

Figure 8: The use of self-learning assessment module

Preferential Learning Style

Even if we each have a preferred style of learning if we are clever we would try to develop a style which combines all four types so that we can adopt the learning style to suit the task to be done. The Figures 9 (a) and (b) show the learning styles of a female social worker and a male management student, respectively.

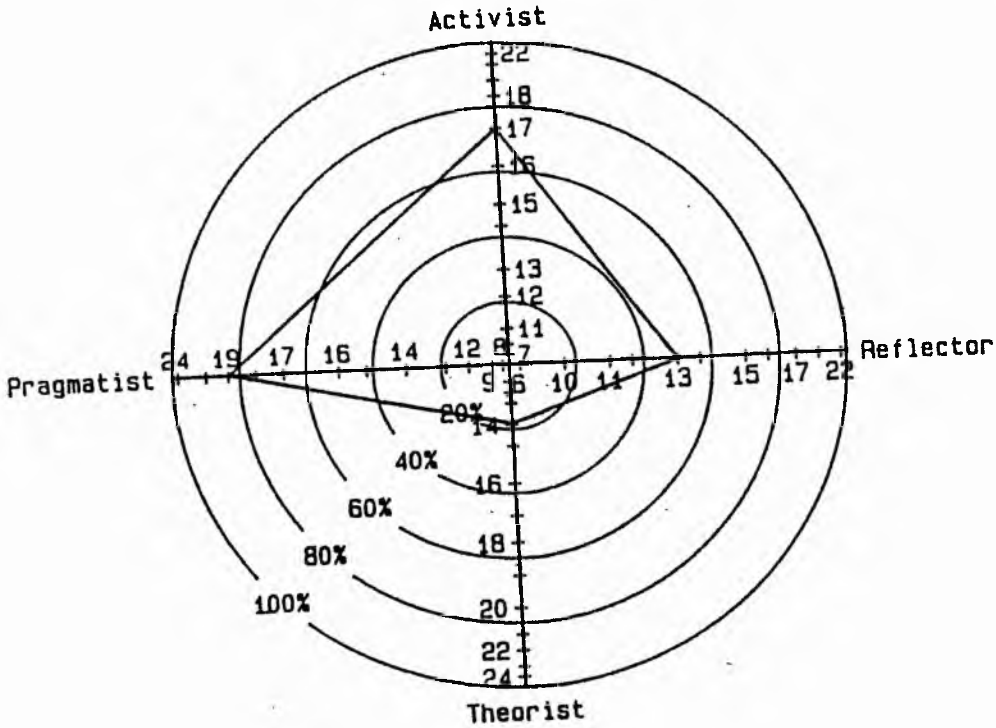

Figure 9 (a) - Female social worker (Kolb, 1984:70)

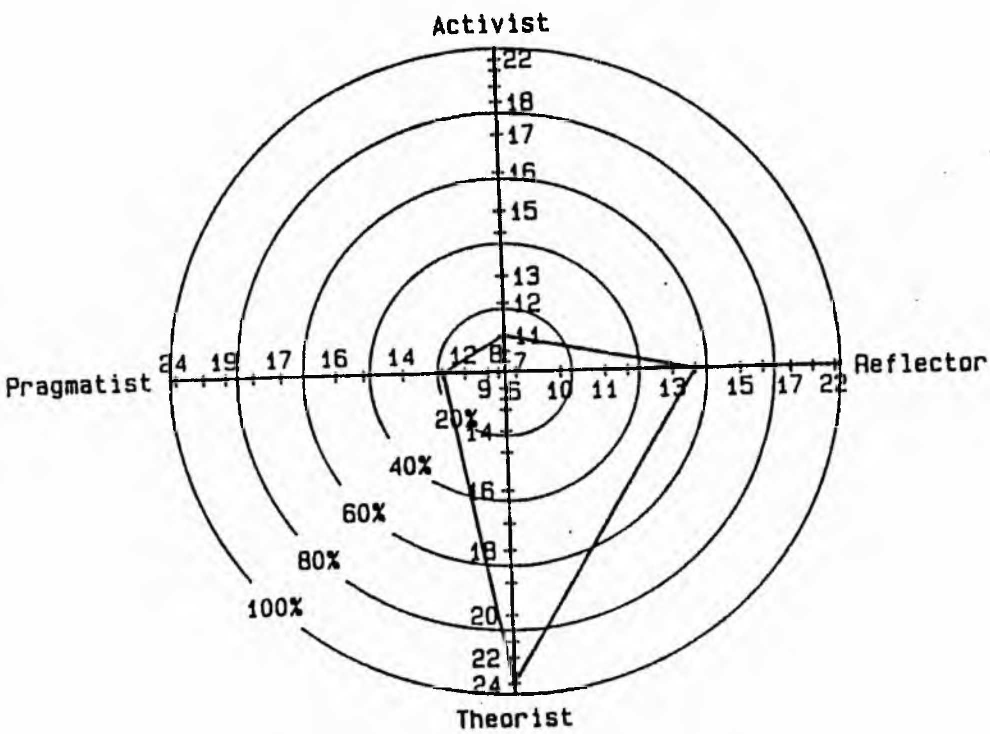

Figure 9 (b) - Male MBA student (Kolb, 1984:72)

The former is engaged in the right profession. She has feelings for people and is concerned with carrying out practical work. The management student on the other hand is concerned with planning and implementation of projects and is therefore more concerned with thinking and planning rather than doing.

Proctoring

"A proctor is a student who helps one or more less advanced students to learn under the guidance of an academic." (Button *et. al.*, 1987).

At the Polytechnic proctors are final-year students who each lead a small group of first-year students in completing the detailed drawings for an artefact from a design prepared by second-year students (Figure 10). As a result of their experience the students suggested that proctoring can be gainfully employed in computing.

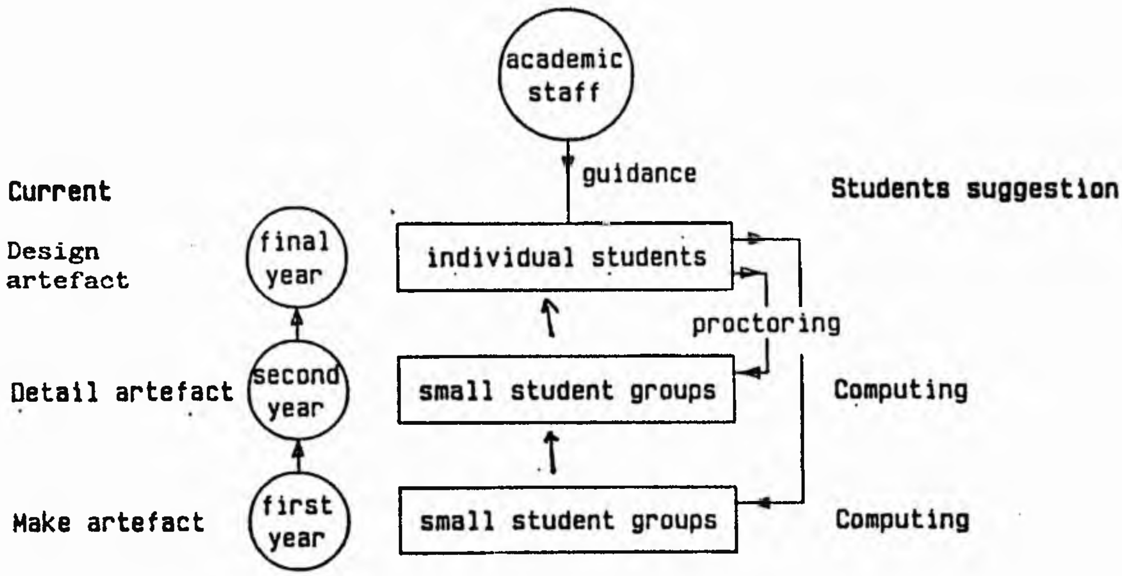

Figure 10: Proctoring in Action

Project Assessment

The Department of Mechanical Engineering of Trent Polytechnic is in the process of developing a prototype for an expert system using a "shell" approach to give advice to students when carrying out a final year project.

The system is to incorporate "expert" knowledge within its database; to incorporate "soft" as opposed to "hard" logic and is capable of providing written reports as well as explaining its line of reasoning when giving advice.

In universities and polytechnics in Britain, graduates in science and technical areas account for 15 to 20 per cent of all final-year students. A major part of the assessment of our final year Mechanical Engineering graduates at Trent Polytechnic is based on project work. It is important to ensure that judgements made on final-year projects are objective. Because of the human element of assessing this type of work there are always going to be subjective judgements made. What we need to do is to make the subjective judgements as objective as possible. Some of us believe that the expert system can help to do this, and we have developed a prototype system that both students and lecturing staff can consult when assessing projects.

The expert system records judgements, includes probability factors and wheights the tasks that students carry out. In doing this we hope we are building up a body of knowledge in our Department which we hope will be useful not only for us but also to others. The program is menu-driven, gives automatic reports, explains how it arrives at a decision, and allows students to assess themselves and to establish what the teachers consider important in carrying out a final-year project. The expert system is only at its beginning although parts of it are already in use.

Expert System / Intelligent Tutor

The Department is also developing an expert system to help manage student learning. What is an expert system? I think the following statement explains it adequately. "Expert systems are computer programs which mimic a human expert by asking questions and giving advice based on the answers." In an in-house development like ours, the expertise is within the academic subjects rather than in artificial intelligence (AI) techniques of programming. An academic can learn how to use an expert system shell faster than an AI programmer can elicit the expert knowledge in the subject to be included in the expert system. The latter are, in addition, few in number and expensive to employ.

In the following two diagrams (Figures 11a and b), we show the development of the expert system first using an AI programmer and then an in-house development which does not use AI programmers. It is recommended, therefore, that the shell approach be preferred to use of AI programming using languages such as Prolog and Lisp.

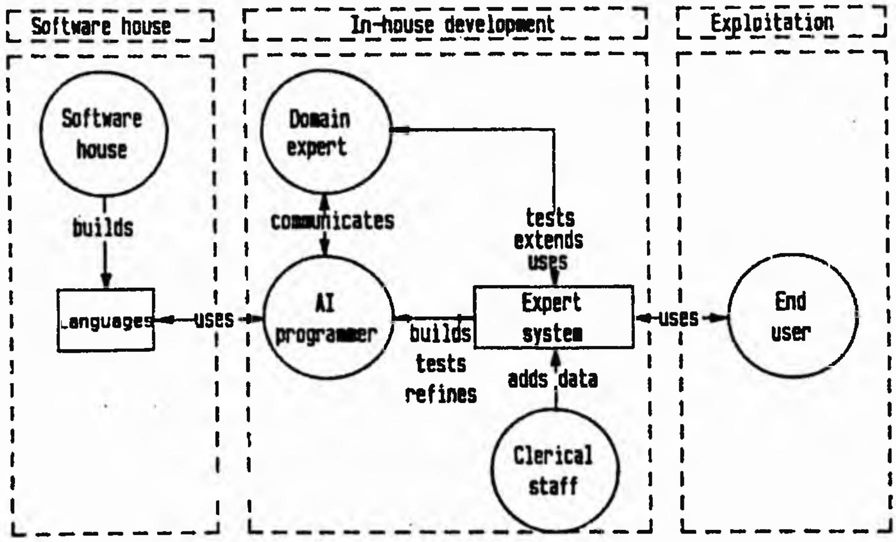

Figure 11(a): Development of an expert system with an AI programmer

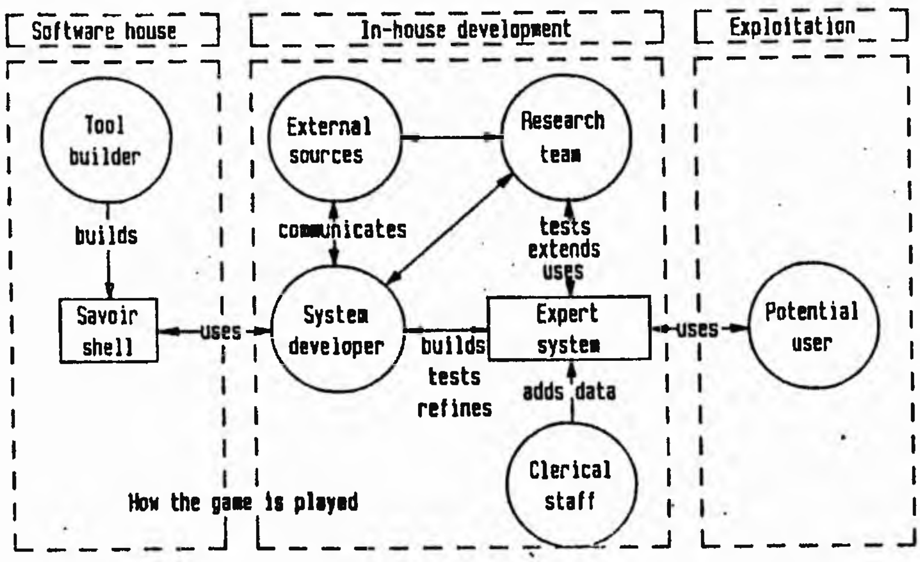

Figure 11(b): Development of an expert system without an AI programmer

The expert system shown diagramatically in Figures 12 and 13 incorporates the educational ideas outlined earlier. Students will consult the system first to determine their existing knowledge and experience and then obtain advice on their learning styles and strategies, before being directed towards appropriate learning material. This material will take the student around the experiential learning cycle. The material being covered by a variety of resources which might include computer media. The student will then return to the expert system which will manage the assessment of the student and provide a measure of subject mastery. Finally the system will direct students to appropriate remedial study when required.

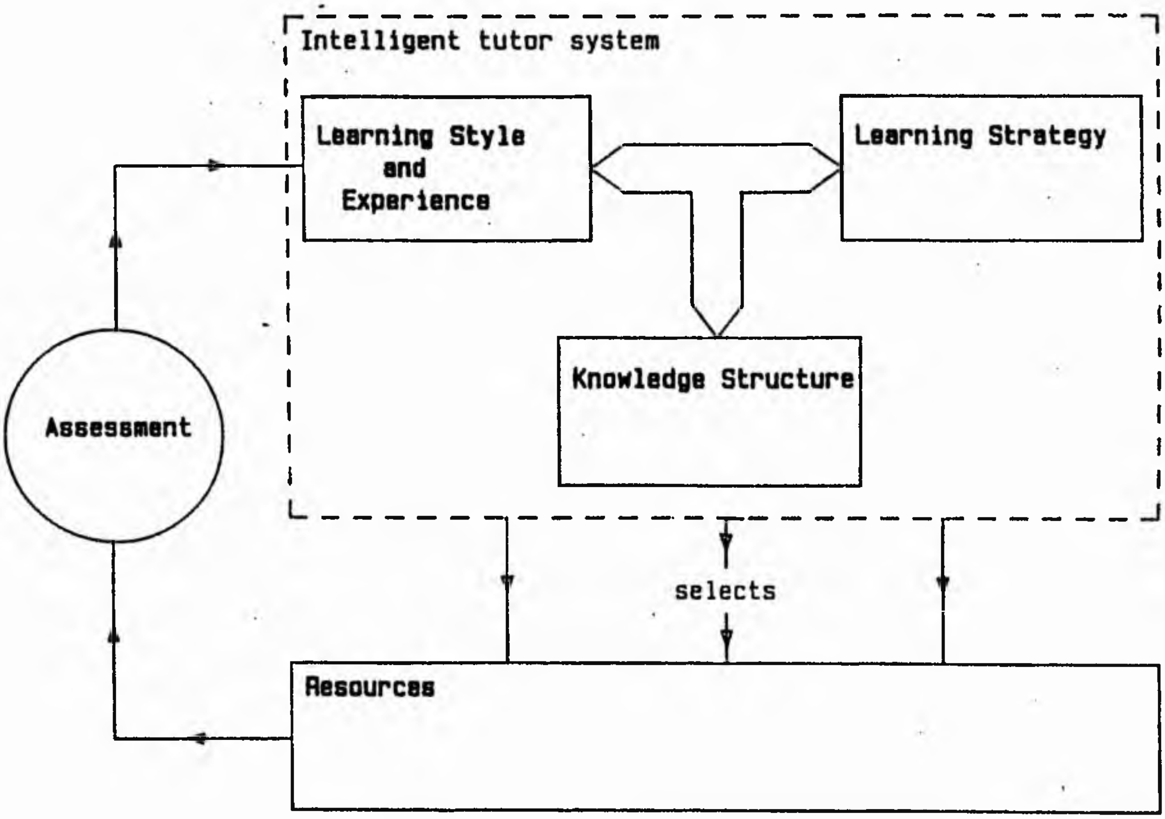

Figure 12: Intelligent tutor shell - independent of content

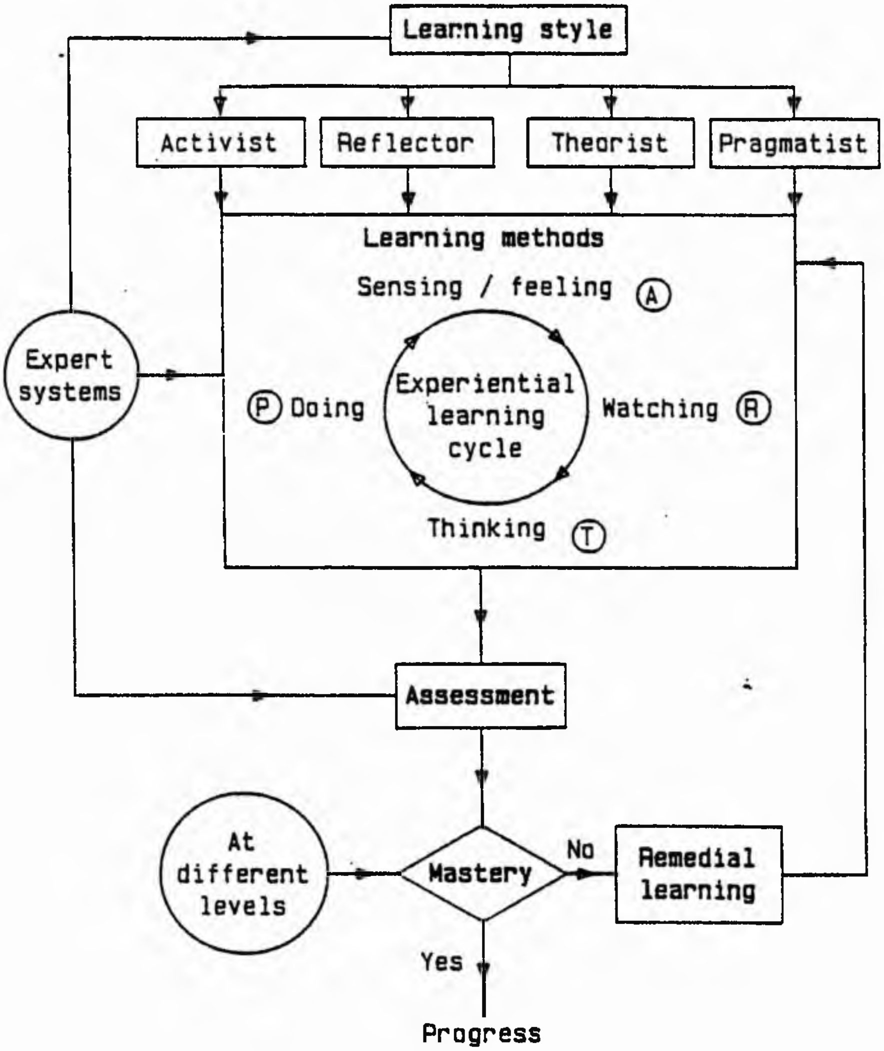

Figure 13: Intelligent tutor shell - dependent of content

The Future

What of its future? We are only at the beginning and we have a long way to go but we think that our expert system on learning styles and methods has great potential. A shell that is "content independent" (Figure 12) can be made "content dependent" (Figure 13) and can be used for different subject material, the material being introduced as and when desired. Hence it can be applied in different settings to suit different requirements.

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A PROPOSAL TO EVALUATE LEARNING STRATEGIES AND STYLES IN ENGINEERING DESIGN EDUCATION

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Faculty of Engineering
Nottingham Polytechnic

Synopsis

Learning strategies and styles and experiential learning are described. A project is proposed which aims to find out how the learning strategies and styles of students relate to what they learn from a computer aided drawing assignment based on the experiential learning cycle. The proposal is related to a knowledge based tutoring system and the Curriculum for Design proposed by Sharing Experience in Engineering Design.

Introduction

The Department is increasingly using educational ideas to improve the learning environment for its students in order to help them to learn more effectively and efficiently about engineering and themselves. The ideas include learning strategies and styles. Beside taking these and other ideas into account in the design, production and development of learning material, Information Technology should be harnessed to help students to learn. In view of the trend towards more project based learning and other student centred activities, it is important that we bring together the educational ideas and the available technology for the benefit of students. The project we are planning aims to do this by incorporating learning strategies and styles questionnaires with one of the computer aided drawing assignments next year. The assignment (Randall 1990) will be undertaken by about 100 second-year undergraduate students and about 15 higher degree students.

The details of the project and its relationship to the long term development of a knowledge based tutoring system are described as is its contribution to developing communication skills as part of Engineering Design.

A knowledge based tutoring system

The components of the knowledge based tutoring system are shown in figure 1. This system is based on earlier proposals (Button and Swannell 1987).

The development strategy for the system is to produce each component separately and then to bring these together. For ease of development, and use by students and lecturers, each component will be mounted in its own separate expert system shell. The component for feedback and assessment was started four years ago (Button and Uzel 1988), and is being used by students and lecturers to assess individual final year undergraduate projects. The component for learning styles has been prepared using the learning styles questionnaire by Honey and Mumford (1986). The study process questionnaire by Biggs (1987) will be used for the component on learning strategies.

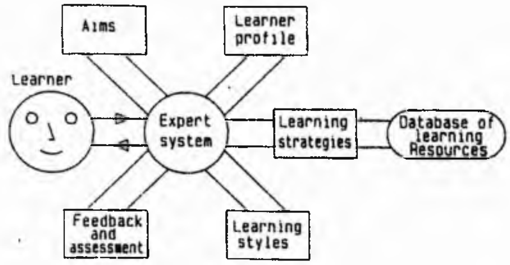

Figure 1. Knowledge based tutoring system

Both of these questionnaires will be used with the computer aided drawing assignment.

Learning strategies

A learning strategy is a description of the way a student chooses to tackle a specific learning task in the light of its perceived demands. O'Neil and Child (1984) report Biggs as expressing a learning strategy as *How we study is a function of why we study*. Recently Biggs (1989) reported that several studies have identified three different approaches to learning:

1 achieving
2 deep
3 surface.

As part of the project an analysis of the students' responses to the study process questionnaire will enable the students, and the lecturers, to obtain a better understanding of their motives and interest in the computer aided drawing assignment.

Experiential learning cycle

Kolb (1984) defined learning as *The process whereby knowledge is created through the transformation of experience.* He also proposed an experiential learning model in which the learner follows a four stage learning cycle:

1 concrete experience (sensing/feeling)
2 reflective observation (watching)
3 abstract conceptualisation (thinking)
4 active experimentation (doing).

This cycle is shown in figure 2. The learning material for the computer aided drawing assignment will be based on this.

Learning styles

A learning style is a broader characterisation of the learner's preferred way of tackling learning tasks in general. Entwistle (1981) stated that *The existence of widely different learning styles prevents there being any possibility of any single correct way to teach or to learn*. To help students identify learning styles, we have selected an instrument from several that are available: the learning styles questionnaire by Honey and Mumford referenced earlier. An analysis of the responses to that questionnaire identifies four learning styles:

1 activist (I will try anything once.)
2 reflector (I would like time to think about this.)
3 theorist (How does this fit with that?)
4 pragmatist (How can I apply this in practice?).

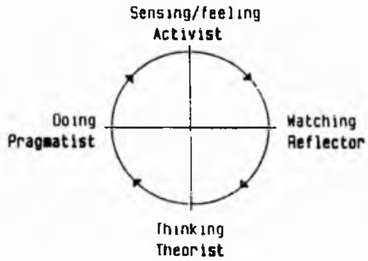

Figure 2. Experiential learning cycle

Figure 2 also shows the relationship of these styles to Kolb's experiential learning cycle. We anticipate that an analysis of the students' responses to the learning styles questionnaire will give the students, and us, some insight into the effectiveness and efficiency of their learning styles.

Curriculum for Engineering Design

The Department bases its curriculum for Engineering Design on Sharing Experience in Engineering Design (SEED 1985). This is set out under the following headings:

1 View of design
2 Requirements for a design curriculum
3 Definition of terms
4 Teaching strategy
5 Teaching and practice
6 Time requirements.

The teaching strategy can be set out under the following headings.

1 The total design activity
2 Core phases

3 Techniques
4 Information
5 Management
6 Assignments and projects.

During their degree course the students cover all of these areas.

In the first year the degree students are taught communications, which ... under the heading of techniques, and they are introduced to the SEED de... activity model, which they use for their design and make project. Throu... the course individual group assignments and projects are used to ... Engineering Design. The final year culminates in a major individual and ... project. Final-year students also carry out proctoring (Button and Sims ... which is where a group of first-year students is supervised by a fina... student while they are doing their design and make project.

The computer aided drawing assignment is aimed at developing the stude... graphic and computer skills during the second year of their degree course

The computer aided drawing assignment

The assignment brief for the students, and for the lecturers, are ... separately.

Assignment brief for students

1 Complete a study process questionnaire.
2 Complete a learning styles questionnaire.
3 Complete a computer aided drawing questionnaire.
4 Examine a plate, vee block and fan blade.
5 Using the McDonnell Douglas Computer Aided Engineering facility
   a complete engineering drawing exercises
   b prepare engineering drawings for a plate, vee block and fan bla...
6 Compare the results from the questionnaires with your gra... assessments.

Assignment brief for the lecturers

1 Find the relationships between the students' results from
   a the study process questionnaires
   b the learning styles questionnaires
   c the prior knowledge of computer aided drawing

   with the graded assessments by the lecturers for
   d the engineering drawing exercises
   e the engineering drawings for the plate, vee block and fan bla...
2 Develop further the learning strategies and learning styles compone... of the knowledge based tutoring system.

Anticipated benefits

1 Students will learn more about themselves by understanding more a... their own learning processes and styles.
2 Lecturers will be able to evaluate the effectiveness and efficien... the assignment against its aims, based on the students' grades and ... responses to the questionnaires.

Acknowledgements

The contribution by the Polytechnic staff development service, which has enabled the development of the learning material for the assignment, is acknowledged.

The project also forms part of a research project into alternative learning methods in engineering design using a knowledge based tutoring system.

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SEED '91 SEMINAR

Project assessment in the BEng Honours Integrated Engineering degree course at Nottingham Polytechnic

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Abstract

In 1989 Nottingham Polytechnic admitted students to the first of the Engineering Council's new Integrated Engineering Degree Programme courses. The structure, rationale and assessment of the Integrated Engineering degree are outlined. The organisation, operation and assessment of a major second year interdisciplinary project first used this year are described.

The origins of the Integrated Engineering degree course

In May 1988 the Engineering Council published a consultative document (Engineering Council, 1988,(1)), "An Integrated Engineering Degree Programme" which defined a new type of broader based engineering degree that was intended to:

- meet identified needs of industry,
- increase access to engineering education by more students,
- provide a balanced curriculum combining the subjects that engineers use most often and directed towards the needs of the majority of engineers.

The qualities looked for by industry when recruiting graduates were identified by the Engineering Council (Engineering Council, 1988,2) as:

- flexibility and broad education,
- able to understand non-engineering functions,
- ability to solve problems,
- knowledge of the principles of engineering and ability to apply them in practical situations,
- information skills,
- experience of project work, especially cross-linked projects,
- ability to work as part of a team,
- presentation and communication skills,
- be active, creative, ambitious, determined and persistent.

To the above we would add that the graduate should be confident and innovative.

The requirement for physics to have been studied at advanced level was eliminated so as to increase the number of students, especially women, eligible to enter the course. In each of the years 1982 to 1986 about 30 000 students entered for both mathematics and physics, however about 25 000 students entered for mathematics but did not enter for physics. The 'A' level pool is therefore doubled by removing this requirement. The course contains appropriate science in the first year to compensate and to reinforce the physics required as a pre-requisite for the engineering core subjects. Mathematics is considered an essential pre-requisite.

The experience at Nottingham is that more broadly based degree courses recruit effectively in competition with other disciplines. Students joining the course in 1990 claimed that the main influences in their choosing this course were:

Non specialised engineering course	79 per cent
Career prospects	33 per cent
Interest	14 per cent
Opportunity to learn a language	14 per cent

Surprisingly, there was a lack of awareness of and interest in the Chartered Engineer designation.

The Department of Trade and Industry provided special funding to enable operation of pilot programmes. Six Universities were selected from thirty applicants to run schemes and of these Nottingham Polytechnic was the first to admit students in September 1989.

The course has been accredited for the purpose of satisfying the academic requirements for registration as a Chartered Engineer by the Institutions of Electrical Engineers, Manufacturing Engineers and Mechanical Engineers.

The nature of Integrated Engineering

Integrated Engineering involves the interrelated study of Electrical, Electronic, Materials, Mechanical and Manufacturing engineering, together with appropriate management topics. All the contributing disciplines are interwoven and Integrated Engineering is distinct from General Engineering in which the principal subjects may be taught without coherence.

Integrated Engineering is an approach in which the sub-disciplinary boundaries which have traditionally divided the engineering profession are diffused or ignored. Integrated Engineering may be seen as a specialism in its own right; the Integrated Engineering graduate will have demonstrated the same capacity for analytic reasoning as honours graduates from degree courses that concentrate on single engineering disciplines.

> "A broad curriculum is as intellectually demanding as a narrowly specialised one. While students may know less, their broader education gives them skills to acquire relevant knowledge quickly and effectively and the flexibility of mind necessary for problem solving in a constantly changing world of work" (Engineering Council, 1988,(2)).

The interdisciplinary nature of engineering was recognised by Baden Fuller 1973 who described a unified approach to engineering education. Many natural laws establish concepts which are fundamental to several of the traditional engineering disciplines. Thus generalised field theory has applications within the realms of electromagnetism, fluid flow and heat transfer; harmonic systems apply to a.c. circuits and to the damped oscillations of masses in dynamics and in structures.

Designing the course

We were able to develop a new engineering degree that would be free from the constraints of existing curricula. The design process is more fully described in Button et al, 1990. The course was designed, validated, accredited and students admitted within one year.

The Engineering Council Consultative Document imposed three essential features:

- Achievement of maximum interlinking between individual subjects, taking advantage of any commonality of subject matter to eliminate duplication.
- Imaginative treatment of the Integrating Studies subject which comprises laboratory, tutorial, design and project work. Integrating Studies is to occupy about 40 per cent of the course.
- The course must have a recognised 'home' even if staff from a number of departments are involved. Team teaching is implicitly required.

The aims of the Integrated Engineering course were discussed and agreed as to:

- provide a broad formation for career development at a time of technological, social and economic change
- emphasise the interdisciplinary nature of engineering
- create a good learning environment
- increase access to engineering.

A guiding principle was that studies in the engineering disciplines were fundamental and studies in other areas were included mainly to support the engineering content. In consequence the mathematics syllabus was identified by engineering lecturers to support the engineering units.

Additional resources obtained to assist operation the course were:

- Department of Trade and Industry £70 000.
- British Petroleum £110 000.
- Eleven other companies £150 000 (cash and kind).

Course Curriculum

The model proposed by the Engineering Council was adopted. Foreign languages were included as options. To introduce a European dimension courses are available in languages and international studies, but attendance at these is not mandatory as we do not wish to deter students from studying engineering. The curriculum is:

Engineering core:
Electrical and Electronic Engineering,
Manufacturing Engineering,
Materials and Strength of Materials,
Engineering Mechanics,
Information Engineering:
Mathematics and computer science.
Physical and Chemical Structures, Processes and Properties:
Balancing and appropriate science.
Enterprise Organisation and People:
Management and business studies, with an emphasis on behavioral theory.
Integrating Studies:
Design projects, laboratory work, tutorials, computers and their use in engineering.
Optional language or International Studies:
Choice of French, German, Italian, Spanish, Mandarin Chinese or International Studies with a European bias.

The weighting of the various curricula are shown in the table below:

	ECTS Units	per cent	Year			Assessment
Engineering Core	62	34.4	1	2	3	Examination
Information Engineering	14	7.8	1	2		Continuous
Physical and Chemical Structures etc	8	4.4	1			Continuous
Enterprise Organisation and People	14	7.8	1	2	3	Continuous
Integrating Studies	82	45.6	1	2	3	Continuous
	180					
Languages	14	7.2	1	2	3	Continuous

Assessment

It is fundamental that students are rewarded for what they do. The time devoted to topics and the marks available to be awarded are consistent. This principle applies to the assessment of topics within individual units and to the weighting of individual subjects when calculating the aggregate marks awarded at the end of each year of study.

It is believed to be important to assess the competence of students in the four engineering subjects in four formal examinations, however it was decided that the remaining subjects would be better assessed by continuous assessment; in so far as they support the engineering core subjects they are examined implicitly.

To progress to the second and final years of the course students are required to:

- pass examinations in each of the four engineering subjects with a minimum mark of 40 per cent,
- complete all coursework in the engineering subjects with a minimum mark of 50 per cent,
- pass continuous assessments in the remaining subjects with a minimum mark of 40 per cent, and
- obtain a mark of 45 per cent or better when the examination and continuous assessment marks are aggregated.

The role of the Integrating Project

Integration within the course is encouraged by team teaching and by distributing the course administration among contributing departments.

Integrating projects are undertaken in all three years of the course. The projects integrate two or more of the principal disciplines. A good project that integrates two disciplines is preferred to a poor project that is contrived to integrate more disciplines. Projects are contained and assessed within the Integrating Studies subject, they contribute 15 per cent of the final assessment during each year of the course. Design methodology is taught during the second year of the course and conforms to the SEED model.

Integrating Studies, including project work, laboratories and some taught material, comprises 46 per cent of the entire course commitment and it is important that the projects developed as learning activities relate to the content of the syllabuses. Projects are a device for learning and teaching and not merely an opportunity to exercise technology learned elsewhere.

The first year project

The first year project is closed ended and is performed by students individually. Students mainly follow taught procedures that are defined in the project brief.

The project integrates the mechanical engineering, materials and manufacturing engineering subjects; it provides an introduction to project based learning and Computer Aided Engineering techniques. Students are required to perform a design analysis on a piston, connecting rod and crank system from an internal combustion engine. A related indicator diagram is provided and students use a spreadsheet to perform a force analysis on the connecting rod for crank angles at intervals of 10 degrees. Students draw the system using both CAD and traditional drawing methods; they select suitable materials for the manufacture of the mechanism and produce a comprehensive report concerning the analysis, design and manufacture of the system.

The second year projects

During the second year students undertake two concurrent projects. The smaller project is the design of a dividing head for use with a Bridgeport machining centre. This project is intended to integrate mechanical and manufacturing elements. Students work in groups of three or four students.
The larger project is the design for manufacture within the polytechnic of a small stabilised antenna platform intended for marine use. Cooperation was obtained from Smiths Industries Aerospace and Defence Systems and rate gyroscopes provided on loan. Smiths Industries gave a presentation on gyro systems and provided product information at the start of the project. At the conclusion of the project suitable designs will be built for use as product demonstrators by Smiths Industries.

The project brief is relatively open ended and requires the students to design a stabilised platform having the following criteria:

Stability of antenna	-	better than +/- 2.5 degrees in pitch and roll
Cost	-	to be designed for construction within a small budget
Size	-	consistent with mounting in a ship model of length 1.5 m

Motion of platform

Ships roll	-	not more than -45 to +45 degrees period 3 seconds
Ships pitch	-	not more than -30 to +30 degrees period 5 seconds
Azimuth	-	to track ships course rate 5 degrees each second

The purpose of the project was to integrate mechanical engineering, electrical engineering, manufacturing engineering and control components of the course. It also includes aspects of the Enterprise, Organisation and People syllabus and as the project was complex it was possible and desirable for students to work in large groups of eight students, each group being a multiple of two groups from the dividing head project. The project groups are deliberately large to introduce problems of coordination and control and thus to simulate the interactions within an industrial design team.

Operational details

The second year of the Integrated Engineering course in 1990 comprised 30 sandwich students. These were divided into three groups of eight and one group of six students. A room was allocated to each project group. The teaching team worked independently to visit each group regularly. The project was timetabled to take place during 3.5 hours on Thursday afternoons over two ten week terms. Formal contact time allocated was thus 70 hours. It was expected that students would make an equivalent directed learning commitment. The project therefore represents 140 hours learning time for each student and each project represents 1120 hours of student effort.

Students were required to complete their designs by the end of the second term and were required to produce their completed reports by the fourth week of the third term. A final assessment meeting was held with each student group in the sixth week of the third term.

Responsibility for operation of the project rested with a team of three lecturers, one from Mechanical Engineering was responsible for coordination and two from Electrical Engineering. Of the two electrical engineers one was a power engineer and the other a digital electronics engineer. Students were encouraged to access specialist lecturers and technicians as required.

Library information on gyroscope systems is somewhat limited. It was desirable that students should make use of material obtained by data base and abstracts searches. To achieve economy a literature search was conducted before the project started and all relevant materials were collected; these were held in the library and made available to students on request.

Assessment

Assessment of large group projects presents a fundamental difficulty. We are required to measure the ability of individual students who may not be distinguishable within their groups. Each group was required to hold formal meetings and to keep minutes. To aid communication within groups and to provide a basis for assessment, groups were required to maintain comprehensive log books containing all work, which was to be signed by the students responsible. Log books were required to be handed in for assessment at the end of each month. It was agreed, with student consultation, that marks would be awarded to reflect both the quality of the final design and the performance of the group throughout the project. It was decided that 40 per cent of the marks would be allocated to represent the approach and progress of the groups during the project and 60 per cent to represent the quality of the final design.

To encourage student evaluation and reflection a colloquia was held half way through the second term and each group was required to present their work to the course team, but not to other student groups. The presentations were video taped and the tapes made available to the student groups.

Final assessment took place in the sixth week of the final term when each group was required to meet the assessors to discuss their project.

At the start of the project students were informed in outline of the method of assessment. Marks allocated to each student would comprise a group component of up to 60 per cent, together with an individual component of up to 40 per cent. An identical group mark would be allocated by the assessors to each member of the group and would reflect the quality of the work presented by the group. Marks would be awarded to individuals following peer appraisal within their group and reflecting individual contributions to the group achievement.
Marks awarded were calculated as follows:

Group mark

Design process method (SEED) and group organisation	12
Evaluation of alternative designs	12
Final design	36
Total group mark	60 per cent

To measure
- quality of submission, presentation, analysis and reasoned selection of methods
- quality of design assessed against specification
- practicality, cost and ease of manufacture
- group organisation and interactions
- interim reports complete and on time
- interim presentation and log books
- effective use of time and resources

Individual mark

The marks awarded for individual contributions were scaled to as follows to reflect the overall quality of the project, thus tending to standardise marks awarded following peer appraisal.

marks available for distribution within the group

40 * number of students in the group * Group mark / 60

These marks were divided between individual students on advice by members of the group, but with the proviso that no student was to be awarded more than 40 marks

To measure - contribution to project
- contribution to group
- effort, achievement and effectiveness

Caution resulting from lack of experience by both staff and students prevented the unrestrained application of peer group assessment to the award of the individual mark component; it was decided that the individual marks would be awarded by the assessors guided by student peer appraisal.

Experiences in assessment

Each project group attended a one hour interview that was conducted by up to six academic staff and which included a senior design engineer from Smiths Industries. This form of examination in which control was retained by the examiners throughout was adopted at the students request and was more searching than a presentation would have been. In the main student groups accepted uniform corporate responsibility for their work and only one student recommendation was made that the individual mark awarded to colleagues should be (positively) weighted. The examiners in addition applied a positive weighting to the individual mark of one student to represent an obvious disproportionate effort.

Students were allocated to project groups according to criteria which included previously demonstrated ability. This tended to ensure that all students had equal opportunity to contribute and to achieve recognition. With only one exception all students said that they were happy in their project groups and elected to maintain the same groups during the final year of the course.

Conclusions

1) When operating an integrating project it is necessary for lecturers to work closely within a team representing all disciplines involved within the project. It is important that lecturers possess the interdisciplinary qualities that students are required to demonstrate.

2) The project highlighted the need for good organisation and cooperation within the project groups. This provided students with a valuable experience that reinforced teaching from the Enterprise, Organisation and People unit. A correlation between a managed approach and effectiveness was clear.

3) The project met the design criteria for the course and enabled students to develop and practice many of the qualities looked for by industry. This is particularly important since the students are following a sandwich course and will spend the following year in industry.

4) Doubt persists that it is possible to clearly identify the contribution of each student working within a group. There remains the possibility that a good student may be disadvantaged by working with less committed colleagues, and conversely. The influence that a group project may contribute to progression or final honours classification should be carefully considered and controlled.

Acknowledgments

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We thank Eur Ing Professor Bryan Button, Dean Faculty of Engineering, Nottingham Polytechnic for his help and permission to publish this paper. The opinions expressed are our own and are not necessarily those of Nottingham Polytechnic.

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Course overview of BEng Honours Integrated Engineering Degree
Course Philosophy and Rationale

by Mr. M. SWANNELL

Presented at Conference on the Tertiary Education in Europe and the Greek Case. Patras, Greece. 18-20 September 1989.

Nottingham Polytechnic
Faculty of Engineering

Course overview of BEng Honours Integrated Engineering Degree

Course Philosophy and Rationale

The Engineering Council together with the Department of Trade and Industry have expressed a need to expand the base from which potential chartered engineers are recruited and to educate engineers with the greatest flexibility and technical capability. Our own positive research in industry confirms that this need is recognised by major employers. This course has been designed in response to this initiative. Validation has already been obtained and accreditation is in hand.

It is necessary to attract more students into engineering against an unfavourable demographic trend and to present engineering in a way that will attract students from opportunities that apparently offer more immediate rewards. The BEng Honours Integrated Engineering degree will present engineering education in an attractive and constructive way in order to maximise recruitment from able sixth formers, while at the same time providing for students who may already be in employment. The course resides within the Faculty of Engineering and is administered from the Department of Mechanical Engineering.

The Integrated Engineering degree will provide broad access to professional careers in engineering. The course will be offered by a variety of full time, sandwich and part time modes which the student may elect to change during the course. Applications from students with a wide range of qualifications at entry will be encouraged and 'A' level physics will not be required. We have considerable experience of admitting students with varying academic backgrounds to higher education and prerequisites have been identified to be taught as balancing studies in the first two terms of the course. Appropriate credit will be granted for previous experience. Students will actively be recruited from Access courses in local Colleges of Further Education and from the HITECC course at Nottingham Polytechnic.

There is considerable emphasis on developing the ability of autonomous learning; this together with a thorough understanding of the supporting principles of engineering will enable graduates to develop during their careers in accordance with the changing demands of technology and their appointed roles.

Innovative and effective learning methods will be encouraged. Learning will tend to be student centred and will include practical problem solving based on projects and problems developed in collaboration with industry. Engineering will be taught in the context of design. Communication skills and the application of computer based methods in particular will be stressed.

Some 40 per cent of student timetabled activity will involve integrating studies. This will include project work, investigative studies, multidisciplinary assignments, role playing and engineering appreciation. This course will provide students with the opportunity of learning engineering through engineering applications.

The course has been designed with the following aims and features.

Generally to:

- provide the educational formation for a professional engineering career.
- provide the engineer with a sufficiently broad foundation to support career development in response to technological, economic and social change.
- create (by means of multidisciplinary projects) a relevant, exciting and enjoyable learning environment in which the student is not overloaded and is motivated to become an autonomous learner.
- provide increased access to higher education in engineering.

Specifically to develop:

- an approach based on the engineering dimension
- an understanding of the integrating role of an engineer
- the personal qualities required of a chartered engineer
- the ability to manage multidisciplinary projects
- a capability to work across traditional subdisciplinary boundaries
- initiative, enterprise and creativity
- the ability to solve problems and to communicate clearly
- an awareness of the commercial and business context of engineering
- an appreciation of industrial relations, industrial law and safety
- an understanding of the role of the professional engineer in society
- an awareness of the applications of computing and microprocessors

Course Curriculum

Subject Areas

The course curriculum consists of eight main subject areas which have been selected to cover most engineering disciplines. These subjects are listed below with the time allocated for each part of the course:

	Total number of hours
Information Engineering	175
Physical and Chemical Structures Processes and Properties	100
Engineering Mechanics	225
Electrical and Electronic Engineering	250
Materials and Strength of Materials	150
Manufacturing Engineering	150
Enterprise, Organisation and People	175
Integrating Studies	480
Total	1705

The core material for the engineering disciplines will be taught in separate subjects, the relationship and integrated nature of the disciplines will be emphasised. This will be achieved through the use of appropriate engineering application and by the use of the multidisciplinary projects contained within integrating studies.

To play as effective and efficient role as soon as possible in industry, a graduate engineer must have a good appreciation of the business and social context of engineering, and a clear awareness of finance and people a resource of no less importance than materials. The effective management of costs and time are also important skills that need to be developed in the graduate engineer.

The Integrated Engineering Degree will provide an ideal vehicle to implement the Enterprise Initiative across the Faculty of Engineering. The course will be directly related to industry, have a sandwich element, contain business and management studies and encourage intitiative, enterprise, creativity and problem solving.

Engineering Student Learning Strategies and Styles: Initial Results

M J Swannell and B L Button*

Abstract

Learning strategies and styles are discussed and contrasted. An initial analysis of the learning strategies and styles of 125 second year engineering degree students is presented. The context of this study in relation to a knowledge based tutoring system is shown. The system is based on assessment of prior knowledge, experiential learning, alternative learning strategies and styles and self as well as tutor assessment.

Introduction

The need to incorporate educational ideas into Higher Education in the United Kingdom is becoming increasingly important with moves towards greater autonomy of study and the use of student centred techniques. Students need to be more aware of the individual learning strategies that can be adopted, as well as their preferences towards a particular style of learning or teaching.

A project (ref 1) is currently being carried out at Nottingham Polytechnic which involves the study of student performance in Computer Aided Design (CAD) related to learning strategies and styles. The students have completed questionnaires on the above as well as a pre-test designed to establish their prior knowledge of CAD and to give them an indication of the learning outcomes from the CAD module to be studied. The preliminary results of this study are presented.

Knowledge Based Tutoring System

The longer term aim is to develop a system based on proposals first presented by Button and Swannell in 1987 (ref 2). The components of the system are shown in figure 1.

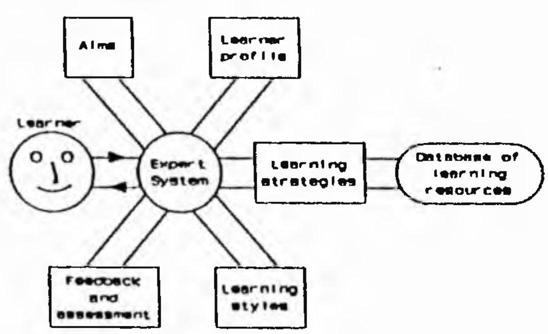

Figure 1. Knowledge based system

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The development strategy is to produce each component separately within its own 'expert system' shell and to bring them together at appropriate stages within the development cycle.

The feedback and assessment component, started by Button and Uzel (ref 3), is at a stage whereby both students and staff can assess project work. At present it is primarily a staff resource designed to facilitate commonality in marking projects and to assist examiners with limited experience of supervising projects. The next phase is to develop a student version to assist students in carrying out a project and to advise them on their progress and performance.

The learning styles component has been prepared based on the questionnaire by Honey and Mumford (ref 4). Students consult the system to determine their preferred learning style and obtain general advice on using this and other styles. A component on learning strategy is to be based on the study process questionnaire (SPQ) by Biggs (ref 5).

Learning strategies and styles

Learning strategy and style are closely related in educational terms. However there is a clear distinction. Learning strategy is concerned with student choice and describes the way that a particular learning task is carried out. O'Neil and Child (ref 6) report Biggs as *how we study is a function of why we study.*

Learning style is related to the broader characteristic of a student's preference for study methods. It is part of the profile that a student brings to a course and although it can be developed, it is intrinsic within the nature of the individual. Entwistle (ref 7) stated that *the existence of widely different learning styles prevents there being any possibility of any single correct way to teach or to learn.* Honey and Mumford identify four learning styles: activist, reflector, theorist and pragmatist. These can be shown to be related to experiential learning as discussed by Kolb (ref 8).

Student strategies

Biggs (ref 5) identifies three main learning strategies, surface, deep and achieving. Table 2 summarises the percentage distribution of learning strategy scores for the engineering students sampled in the survey. Scores above the norm indicate that students normally select this strategy in their studies, a norm score indicates that they sometimes use this strategy, and below the norm students rarely use this strategy.

Table 2. Learning strategies

	Above	Norm	Below
Surface	26	39	35
Deep	22	48	30
Achieving	36	41	23

The table indicates that most students select a deep (22 per cent) or an achieving (36 per cent) strategy. However a significant number (26 per cent) believe that a surface approach will provide them with a route to an engineering degree.

Motive - strategy correlations

The reasons for studying have been correlated with the way that the students study. Figures 2 to 4 show these correlations for the three learning strategies.

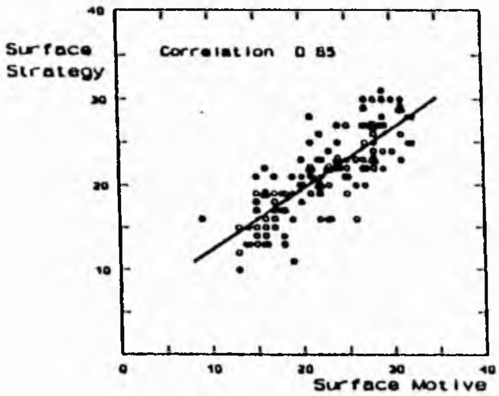

Figure 2. Surface learning

This shows a good correlation (coefficient of 0.65) between surface motives and strategies.

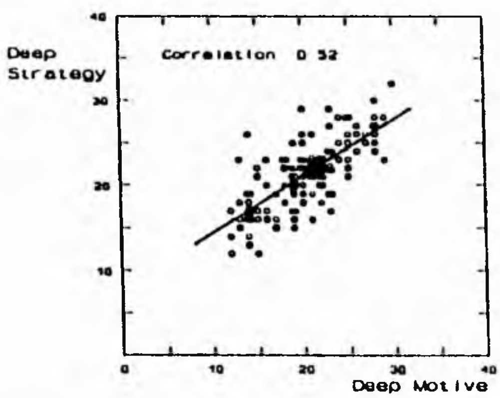

Figure 3. Deep learning

Again a correlation (coefficient of 0.52) is demonstrated.

The study of motives and strategies for achieving learning did not show such a strong correlation with a coefficient of only 0.10 (see figure 4).

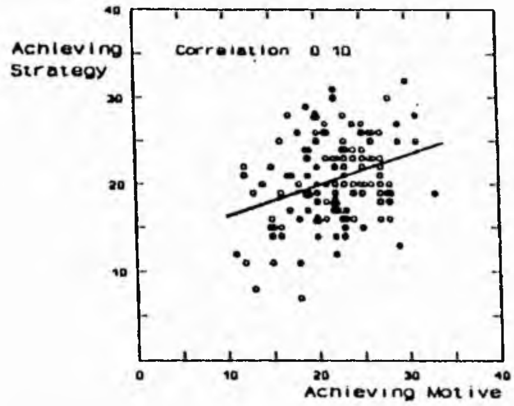

Figure 4. Achieving learning

Student styles

Table 1 shows the percentage distribution of style scores for the 125 second year engineering students. A higher than norm score for a style indicates that students have a strong preference, a norm score indicates a moderate preference and below the norm a low preference.

Table 1. Learning style

	Above	Norm	Below
Activist	41	41	18
Reflector	47	39	14
Theorist	41	21	38
Pragmatist	26	39	35

As a group the engineering students do not have a strong preference towards a single learning style. One interesting factor is the low percentage of pragmatists. It will be interesting to compare the style scores at the end of the course when students have received industrial training. A typical learning style profile is shown in figure 5.

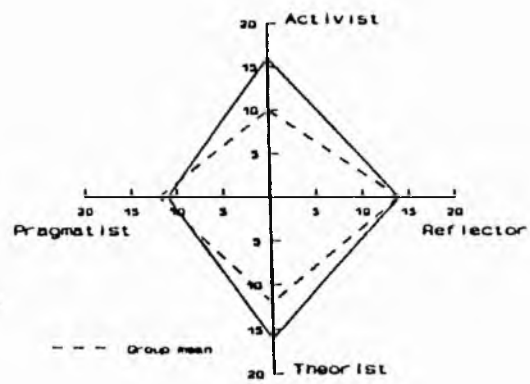

Figure 5. Learning style profile

The mean style scores in the figure can be misleading in that they indicate that students have a well rounded learning style profile with similar scores for each style. In practice most profiles tend to be strong in certain style areas and weaker in others. This is illustrated by the individual profile shown which is strong in the activist and theorist styles and only the mean for the group in the other two styles.

Concluding remarks

Initial analysis of the data generally confirms that there is a relationship between the way that students study and their reasons for studying. The indications are that second year engineering students at Nottingham Polytechnic have reasonably balanced learning styles, with surprisingly few students having a strong pragmatist style.

Future work

Future work will include a study of the relationships between learning strategies and styles with performance in three areas:

- assignment on CAD learning module based on experiential cycle
- project based assessments
- terminal assessments

It is also planned to compare the characteristics and performance of full-time and part-time students.

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