Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

2

LEARNING APPROACHES AND STUDY PATTERNS OF DISTANCE EDUCATION STUDENTS IN MATHEMATICS

Glenda Joy Anthony

1991

LEARNING APPROACHES AND STUDY PATTERNS OF DISTANCE EDUCATION STUDENTS IN MATHEMATICS

A thesis presented in partial fulfilment
of the requirements

for the degree
of MPhil
in Mathematics Education at

MASSEY UNIVERSITY

Glenda Joy Anthony
1991

ABSTRACT

Teaching is an activity that assumes an understanding of learning: to teach in a way that encourages changes in conceptions and develops understanding, one must be aware of how students learn. This research examines and analyzes the learning processes used by extramural students studying mathematics. Findings indicate students exhibit learning approaches that can be classified into Surface, Deep and Achieving approaches. Each approach produces qualitatively different outcomes both in performance and in affective outcomes. The role of worked examples was found to be very important in the learning process: the purpose and manner in which the example was studied differed depending on the learning approach employed. Metacognitive behaviour is seen to be an important mediating factor in determining the individual effectiveness of an approach to a specific learning situation. In particular the monitoring of one's understanding is a significant factor in the value of self explanations and construction of understanding by the student. There is also evidence that students' perception of learning mathematics and assessment affects the approach to learning.

ACKNOWLEDGEMENTS

I wish to express my appreciation for the guidance and inspiration provided by Associate Professor Gordon Knight. His supportive comments and encouragement have been a great motivation to complete this research.

I also wish to acknowledge with gratitude the support and encouragement Dr Gillian Thornley has provided. Her example as a mathematician and her encouragement were instrumental in my furthering studies in mathematics education.

I also thank Dr Gillian Thornley and Dr Mike Hendy, in their role as course controllers for 60.102: their cooperation has enabled this research to be undertaken. A special thanks also to the many extramural students of 60.102 who took the time to complete questionnaires, provided helpful feedback and discussed at length their learning approaches and experiences as an extramural student. I hope by raising students' awareness of the "process of learning" in mathematics there is some mutual benefit to myself and the respondents.

CONTENTS

ABSTRACT ii

ACKNOWLEDGEMENTS iii

1 INTRODUCTION

1.1 Background 1

1.2 The Specific Problem 2

1.3 The Research Objective 3

1.4 Relevance of the Objective to Education 4

2 LITERATURE REVIEW

2.1 Introduction 6

2.2 Developments in Cognitive Psychology 7

Introduction 7

Constructivism 8

Knowledge Dependent Learning 10

Metacognition 11

2.3 Biggs' Model of Learning 13

2.4 Approaches to Learning 15

Types of Approaches 15

Approaches used by Tertiary Students 17

Factors Affecting Approaches 21

2.5 Use of Worked Examples and Exercises 25

2.6 Summary 32

3 THE RESEARCH PROCESS

3.1 The Research Method 33

3.2 Justification for the choice of Methodology 37

4	**STUDY PATTERNS - RESULTS Part 1**		**42**
	4.1	Introduction	42
	4.2	Study Patterns Diary	43
	4.3	Time Spent on Section 4	43
	4.4	Study Patterns	46
	4.5	Examples as a Source of Learning	48
	4.6	Role of Assessment Material	56
	4.7	Summary	59
5	**LEARNING APPROACHES - RESULTS Part 2**		**61**
	5.1	Study Process Questionnaire	61
	5.2	Scoring the Study Process Questionnaire	63
	5.3	Interpreting the Study Process Questionnaire Distribution of Scores	64
	5.4	Approach Scores and Outcome	68
	5.5	Presage Factors Affecting Learning Approaches	73
		Motivation	73
		Plans for further education	75
		Time	76
		Age	77
		Prior knowledge	79
		Student perception of course organization and assessment	80
		Student perception of learning mathematics	84
	5.6	Student Profiles of Approaches to Learning	90
		Surface Approach	90
		Deep Approach	93
		Achieving Approach	96
		Deep Achieving Approach	98
	5.7	Metacognitive Behaviour	101
		Examples of metacognitive behaviour	102
		Levels of metacognitive behaviour	107
	5.8	Summary	109

6	**CONCLUSIONS**	110
6.1	Approaches to Learning	110
6.2	Metacognitive Behaviour	112
6.3	Prior Knowledge	114
6.4	Student use of Textual Material	115
6.5	The Context of Learning	116
7	**RECOMMENDATIONS FOR FURTHER RESEARCH**	119
8	**BIBLIOGRAPHY**	122
9	**APPENDICES**	128
1	Study Patterns Diary (SPD)	128
2	Questionnaire	129
3	Study Patterns Questionnaire (SPQ)	130
4	Interview Questions	134
5	Raw SPQ Scores	135
6	Decile scaled SPQ Scores/Categories	136
7	Chi Square Analysis for Biggs' science versus respondents' Deep Approach scores.	137
8	Comparison of mean Approach Scores of Science and Mathematics.	138
9	Correlation of Strategy/Motive Scores	139

1 INTRODUCTION

1.1 BACKGROUND

Distance education in mathematics at Massey University was first established in the 1960's. Despite the rapid growth in the last 30 years, both in New Zealand and worldwide, relatively few publications or research projects relate to distance education in mathematics.

In the past much of the research in higher education has used an input/output model. Input variables such as instructional design or teaching method have either been observed or systematically varied and have been linked to output variables such as grades or withdrawal rates.

Much less attention has been given to the intermediate step of process: of how the students learn, on ways in which students approach their study tasks, and also on the learning styles they commonly employ. (Kember and Harper, 1987)

Research needs to focus now not on general mechanisms of learning but on learning of specific subject matter in its natural context. (Ramsden, 1988) In particular research concerning the process of learning as an extramural student rather than the content of distance education courses is needed to ensure the provision of the best possible service to students. (Knight, et al. 1990)

Teaching is an activity that assumes an understanding of learning: to teach in a way that encourages changes in conceptions and develops understanding, one must be aware of how students learn.

1.2 THE SPECIFIC PROBLEM

Entwistle and Ramsden (1983) expressed the view that too little attention had been given to the process of learning and the effects of teaching on it.

> *"Lecturers tend to think that the context of student learning is not of great importance; they attribute success or failure to the characteristics of the student, not to their teaching. As a consequence we know remarkably little about the effects of lecturers' teaching, assessment, and course organization on student learning."*

The context of mathematics distance education learning is quite different to that of the full time tertiary student. Teaching is done largely through textual material, consisting of purpose written material in the form of Study Guides, text-books and regular assignments.

For example the subjects of this research are studying 60.102 Linear Algebra and Geometry, which is based on a purpose written text Geometry and Linear Algebra (Thornley and Hendy, 1989). The text contains information of a primary nature such as definitions, theorems and proofs, expositions and illustrations of the application of the primary information. Exercises and quiz sections provide opportunities for students to explore and assimilate the concepts, and to develop problem-solving skills and strategies. Study guides provide supplementary explanations, worked examples and suggested exercises and hints. Regular assignments indicate to the tutor and student how well a student is grasping the information and developing mathematical techniques and concepts.

The problem arises in that written presentation of the assignment, often representing the result of several draft attempts, does not necessarily reflect the learning processes employed by the student. Specific learning strategies used by the student and difficulties the student encountered while completing the exercise may not be evident in the final presentation.

Thus, although tutors may have knowledge of content areas which prove to be difficult, mistakes which are likely to occur and a record of assignment grades, little is known about how the student studies the given material, what parts of the material are the most important to the student, how much time the student spends on each section and what activities are beneficial for the learning of mathematics.

This information, relating to the way students learn, pertains to the "process" stage of Biggs' Model of Learning. Biggs (1987b, 1989) has conceived of students learning in three stages: **Input**, **Process** and **Product**. The process can be seen as the way in which the student approaches the learning task of the input phase.

1.3 THE RESEARCH OBJECTIVE

The purpose of this research is to examine and analyze the learning processes used by extramural students studying 60.102 (Linear Algebra and Geometry).

An examination of the process phase of student learning will gather data on:

1. the study patterns: the way in which students approach their study tasks.

2. the learning styles they commonly employ.

3. the extent to which these reflect the effects of teaching and assessment demands.

1.4 RELEVANCE OF OBJECTIVE TO EDUCATION

The student approach to learning is a composite of a motive and an appropriate strategy, categorized by Biggs (1987a, 1987b) into three types:

1) Surface - students who are learning in order to get by with minimal effort, or pass their subject with out aiming for high grades. Students are likely to focus on the core essentials and rote learn them.

2) Achieving - students who are motivated to achieve high grades and organize their work.

3) Deep - students who are intrinsically motivated tend to extract most meaning from their learning; they read widely, relating new content to what they already know.

Biggs (1989) urges for the further study of students' learning: what misconceptions they hold, what specific activities or processes are involved in carrying out key tasks and what constitutes deep or surface approaches to handling those tasks.

There is strong evidence (Biggs, 1987b; Marton and Saljo, 1976; Watkins, 1983) that different ways of approaching learning tasks will produce characteristically different outcomes:

- surface approach leads to the memorization of factual details, lack of structure and low involvement.

- achieving approach leads to outcomes structured in terms compatible with course requirements involving ego enhancement rather than personal commitment.

- deep approach leads to qualitatively structured outcomes involving personal commitment.

Analysis of study patterns and strategies to provide profiles of learning approaches may suggest ways to enhance teaching material to maximize deep and minimize surface approaches. If we had more knowledge of how distance education students study, what processes they used and which are related to successful outcomes, we would be able to provide appropriate course material and feedback on assignments.

> *"Until study patterns are better understood it is unwise to purport to know and advise students of the recommended way to study." (Roberts, 1986)*

A specific area of importance is the students' use of textual materials. Design of textual materials in distance education has often reflected the view that learning from text is primarily a function of how well text-writers can influence or manipulate learners. In courses involving large amounts of written material devices such as objectives, advance organisers, in-text questions, headings and assessment items have become widely used. Evidence from distance learning research (cited Marland et al. 1990) has cast doubts on the alleged values of many of these common devices and led to a growing doubt of some commonly-held assumptions about what is helpful to students.

The uncertainty surrounding the value of the traditional approach to writing instructional text has prompted calls for studies of how distance learners actually use and learn from textual materials. Advocates of this research (Baird and White, 1982) recommend undertaking descriptive research in real-world learning contexts to provide a basis for the development of grounded theory. Such research, it has been suggested, should be directed at finding out how distance learners use and learn from the materials provided to them.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this literature review is to discuss the growing body of literature associated with approaches to studying and student learning. This provides both a theoretical perspective for the study and a background for the choice of research method.

Specific publications relating to distance education in mathematics are relatively few and only a small percentage of those which do exist have a research base (Knight et al, 1990; Svenson et al, 1983). However there has been extensive research on study processes of full time tertiary students (Biggs,1987b; Entwistle and Ramsden, 1983; Ford, 1981; Kember and Harper, 1987b). Further research by Harper and Kember (1986) and Watkins (1983) showed that the results of investigations into learning approaches by full-time student are applicable to distance education students.

The student's use of the textual material and its affect on learning processes employed has also been examined; in particular material relating to the use of worked examples.

As a background to the more specific literature, some recent developments in cognitive psychology which provide a theoretical framework for the study are reviewed.

2.2 DEVELOPMENTS IN COGNITIVE PSYCHOLOGY

2.2.1 INTRODUCTION

The changing beliefs about learning in general, and mathematics learning in particular, reflect the effects of research in cognitive psychology over the last decade. The human learner is no longer conceived as a passive information storage system, but as a self-determining agent who actively selects information from the perceived environment, and who constructs new knowledge in the light of what that individual already knows (Shuell, 1986).

There are three important consequences of this view: (Biggs, 1989; Resnick, 1990)

1. The content of learning is not incorporated from without, but is constructed from within, from data that are selected and interpreted according to the learner's motives, and existing conceptual frameworks.

2. The learner is aware of these processes of cognition and can control them; this self awareness, or metacognition (Flavell, 1976), significantly influences the course of learning. People can deliberately optimize their performance, and learn from having become aware of their mistakes.

3. Learning is founded on a specific knowledge base that varies in its content and procedural aspects from task to task. Process analysis of academic tasks can provide a basis for teaching those tasks.

It is clear from the above perspective that research of student learning should focus on the student in context, carrying out particular tasks. The changes in conceptions of the nature of learning have implications for the enhancement of distance education teaching and learning.

2.2.2 CONSTRUCTIVISM

Although contemporary research in mathematics learning commonly places strong emphasis on students as active participants in the learning process, this conception of learning is neither new nor novel. Leder and Gunstone (1990) provides several examples of constructivist positions being advocated: Piaget is a widely recognized example of a view of learners predicated on active student participation in learning. Wittrock's generative learning model, although more recently elaborated with reference to science learning was described in an earlier form in the context of mathematics learning.

The notion of constructivism is particularly congruent with the notion of self directed learning of the distance learner, in emphasising active enquiry, independence in the learning task and indivduality in the construction of personal understandings.

> *"Learning cannot be simply a matter of memorizing or "acquiring" knowledge. Instead, it is a constructive process which involves actively seeking meaning from events. Comprehension of texts is an active constructive process, not merely reception or rehearsal of information. Personal knowledge of the world is organized into associated networks or schemata." (Candy, 1989, p 107)*

Activity alone, in the form of reading text, doing exercises etc. will not necessarily result in understanding and retention. A point not appreciated by students who claimed to have spent many hours studying without success in understanding the content. It is necessary for students to have an appropriate system of personal constructs (schemata) to provide the "anticipatory scheme" (Candy, 1989) to make sense of any given situation.

The traditional view of instruction as direct transfer of knowledge does not fit a constructivist perspective. Constructivism in education is concerned with two facets: how the learner construes (or interprets) events and ideas, and how s/he construct (assemble) structures of meaning. Correspondingly, instruction must provide information for learners' knowledge construction process and where necessary instruction must also directly teach knowledge construction strategies (Resnick, 1990).

Course material which will facilitate learning that requires active construction by the learner rather than replication of information, must focus not totally on facts but on how one arrives at the concept.

> *"The method of mathematical instruction cannot be the imparting of mathematical "truths" but must instead, be the setting up of circumstances which will induce the learner to achieve in his own mind - that is to reconstruct....The task for the trainer shifts from "mere description" of the constructs the learner is to acquire, to attempting to understand the existing understandings and meaning systems of the learner." (Van Glasersfeld & Smock, cited Candy, 1989)*

In summary, constructivism focuses attention on the basic abilities that underlie performance rather than on the performance itself. The theory makes the strong distinction between information, that which can be given or transmitted, and knowledge which must be constructed by the learner.

2.2.3 KNOWLEDGE DEPENDENT LEARNING

There is extensive research suggesting that both reasoning and learning are knowledge driven. A foundation of domain knowledge is requisite to the efficient and effective utilization of strategic knowledge. Thus knowledge is constructed by learners on the basis of what they already know, the frameworks so constructed becomes the means by which learners interpret their experience.

Those who know more about a particular domain generally understand and remember better than those with only a limited background (Alexander, 1988; Chi and Bassok, 1989). To illustrate, Alexander cites examples of research in reading and mathematics in which students low in conceptual knowledge frequently lacked strategic maturity. They had problems:

(a) realizing when they understood,

(b) determining the amount of practice they required and

(c) deciding what strategies would be most appropriate.

As well as domain knowledge research has recently focused on knowledge of cognition or "metacognition". Metacognition is seen as am important factor in determining how students deal with the knowledge they have.

2.3.4. METACOGNITION

Developing an awareness not only of the nature of learning in which one is engaged, but also of one's own learning processes, may be a prerequisite for learning how to learn effectively; such an awareness is called metacognition (Ford, 1981).

Students learning metacognitively plan ahead. They define their goals and develop a strategy for reaching them. They monitor their performance while using that strategy, correcting errors, and then check at the finish to see that they have indeed completed what they set out to do.

Students may differ in the extent to which they are aware of the nature of their learning: their own role in determining what is learned, how it is learned, what is required of them, and what they must do to achieve particular results in particular contexts.

Proponents of the expert versus novice theories agree that expertise is not primarily associated with the quantity of what is known but rather with the quality of processing one uses given the material at hand. Those who monitor and regulate their cognitive processing appropriately during task performance do better than those who do not engage in such strategic processing.

Chi & Bassok (1989) note differences among learners in their tendency to monitor their understanding as they work. Better students seem to attend closely to and properly assess their own state of understanding. When processing physics examples they found that good students generated a large number of statements that reflected failure to comprehend:

> *"The advantage of having an accurate monitoring of ones understanding is that the realization that one does not understand should elicit attempts to understand." (Chi & Bassok, 1989, p 243)*

A realization of comprehension failures triggers episodes of self-explanations. The fact that these self-generated explanation, by contrast to those supplied by the text, will necessarily be consistent with the students understanding, should facilitate greater understanding of the material.

In contrast, poor students not only did not realise that they did not understand, in fact, they thought more often that they understood.

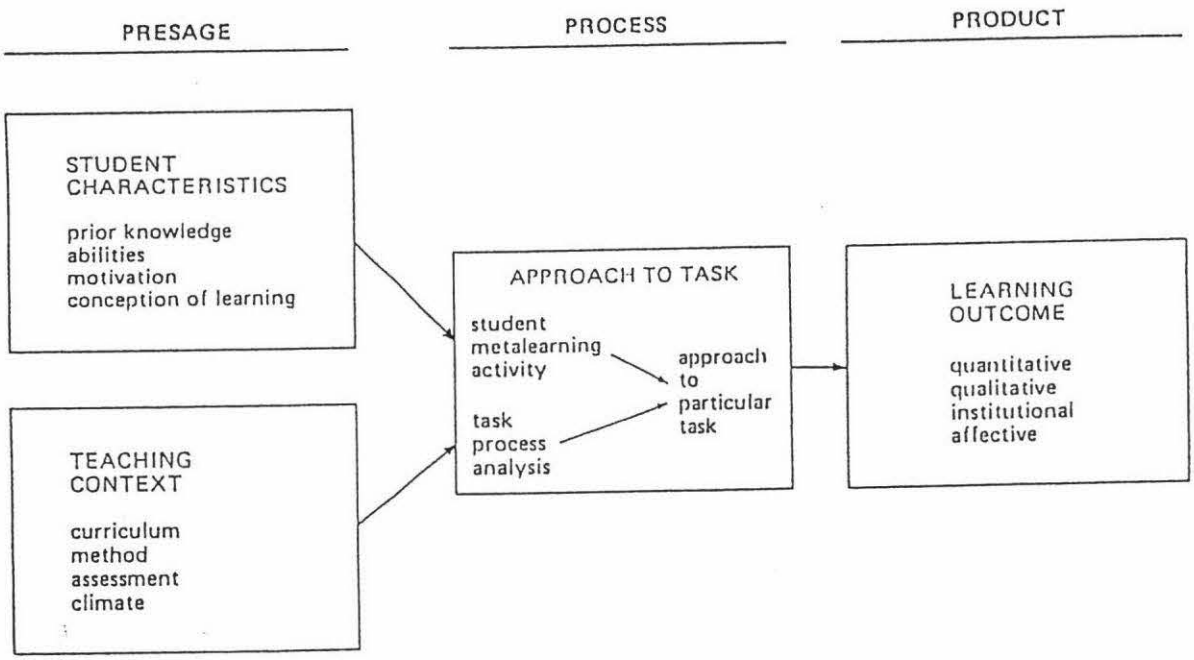
Such awareness of the process of thinking is particularly important in self-directed learning. Students who are more aware of their own thinking processes are more likely to take responsibility for what and how they learn, becoming active rather than passive learners.

In summary cognitive theories tell us that learning occurs not by recoding information but by interpreting it. Effective learning depends on the intentions, self-monitoring, elaborations, and representational constructions of the individual learner.

This is reflected in Biggs' Model of Learning which is an important feature of this study.

2.3 BIGGS' MODEL OF LEARNING

Students undertake, or avoid, learning for a variety of reasons; those reasons determine how they go about their learning; and how they go about their learning will determine the quality of the outcome. Biggs (1987, 1987b, 1989) summarises this chain of events in an integrated system, comprising three main components: presage, process and product as illustrated in Figure 1.



Presage Process and Product in Student Learning

Figure 1.

First, presage factors exist prior to learning, and relate to the student, and to the teaching context. Students begin distance study with certain abilities, previous knowledge about the subject matter, expectations and motivations for learning, conceptions of what tertiary study is about, age and experience.

The teaching context contains all those factors which are under the teacher's or the institution's control: course structure and content, methods of teaching and assessment, the difficulty of the task, the nature of the task content, all of which also generate a "climate" for learning, which has important motivational consequences.

Students interpret this teaching context in the light of their own preconceptions and motivations, giving rise to a metacognitive activity focusing on learning itself, not on the content of learning. This activity of "metalearning" (Biggs, 1985) enables students to derive their approaches to learning. Approaches to learning constitute the Process Factor of Biggs' model and will be discussed more fully in the Approches to Learning section below.

The Product refers to the learning outcome, which is determined by the approach adopted. This outcome may be described:

- quantitatively, or how much was learned;
- qualitatively, or how well it was learned;
- institutionally, to what grades it was accorded.

In addition, affective outcomes relate to how students feel about their learning; these are important in determining motivation for future learning.

Biggs' 3P model represents an interactive system in equilibrium; the components of presage, process and product levels tend to be in balance, and variations to any component affect the whole system. Thus a particular conception of learning and teaching leads to one approach rather than to others, which in turn leads to a characteristic outcome. These approaches are discussed in the next section.

2.4 APPROACHES TO LEARNING

2.4.1: TYPES OF APPROACHES

There is a consensus in the research literature that students in tertiary education manifest a limited number of different approaches to learning. There have been a number of schemes for categorising these approaches to learning. Ausubel (1963) used the terms meaningful and rote learning and Wittrock (1974) referred to generative and reproductive processing. Marton and Saljo (1976) distinguished two different "levels of processing", surface-level processing and deep-level processing, while Biggs (1978) originally used the terms utilizing, internalising and achieving.

While there are differences in earlier terminology, there is now a general agreement among researchers (Biggs 1987a; Entwistle and Ramsden, 1983; Watkins, 1983) that approaches can be categorized into three types: Surface, Deep and Achieving, as specified by the PROCESS FACTORS of Biggs' Model of Student Learning.

Students devise strategies to solve the problem their motives have defined for them thus the approach the student takes is a composite of a motive and an appropriate strategy. The Approach determines the way the student goes about learning in the following manner:

SURFACE: The motive is to meet institutional requirements minimally; the strategy is limiting the target to essentials that may be reproduced through rote learning.

DEEP: The motive is intrinsic interest in the content; the strategy is discovering meaning and acquiring competence by reading widely, interrelating with existing knowledge.

ACHIEVEMENT: The motive is ego enhancement through high grades; the strategy is organising time, working space, and syllabus coverage, in the most effective way.

Surface and deep strategies describe ways in which students engage in the actual task of learning. Deep level learning strategies require learners to be aware of their motives for learning and to be able to control which strategies to use and accept. In contrast, achieving strategy describes the ways in which students organize the temporal and spatial contexts in which the task is carried out.

Thus it is possible for students to combine an achieving approach with either a surface, or a deep approach. For example, a student may perceive that the way to obtain high marks consists of selectively rote learning in an organized and systematic way (Surface Achieving Approach); or more usually, by reading widely and seeking meaning in an organized and systematic way (Deep achieving Approach).

Because strategies are characterized by planful and intentional use, their susceptibility to motivation effects may be considerable. Successful independent learning of distance education students would require that one has available a collection of strategies and be convinced that the strategies are important, effective and efficient.

2.4.2 APPROACHES USED BY TERTIARY STUDENTS

Significant research, over the last decade, has specifically addressed the area of learning approaches in tertiary institutions, (Biggs, 1985, 1987b, 1989; Entwistle & Ramsden, 1983; Watkins 1986). Parallel research with distance education students (Kember and Harper 1987, 1987a; Small 1986; Watkins 1986; Marland et al, 1990) found similar learning process patterns and demonstrated that the constructs derived from research on full time internal students are relevant to part-time distance learners.

Findings based on very different research methodologies such as large scale questionnaires, sophisticated statistical techniques and indepth interviews have emphasized that individuals are very consistent in their approach to learning and the role in which the learning context plays in influencing the approach the student adopts.

A study of tertiary students by Watkins (1986) showed that students approach a learning task in one of two ways. Some students begin with the intention of understanding the meaning of the learning task, they focus attention on the content as a whole, try to see connections between different parts, and think about the task as a whole; a deep level approach. Other students adopt a mechanical unthinking approach, they rote learn and focus on elements rather than the task as a whole; a surface level approach.

The surface, deep, and achieving approaches represent general orientations of students. While the predominant approach to learning will be one normally adopted for a learning task, a student may adopt the alternative approach for a particular task (Kember and Gow, 1989).

There is presently a considerable amount of research linking learning approaches to the outcomes of learning, whether these approaches are operationalized by questionnaire (Biggs, 1987b; Entwistle and Ramsden, 1983) or by interview (Marton and Saljo, 1976; Watkins, 1983). Biggs (1989) cites strong evidence that different ways of handling a task (in curriculum areas of literacy, history and computing science) will produce characteristically different outcomes:

- The surface approach leads to retention of factual detail at the expense of the structural relationships inherent in the content to be learned; is effective for recalling unrelated detail, which frequently leads to low grades. Emotional or affective outcomes are feelings of dissatisfaction, boredom, or outright dislike.

- The deep approach leads to an understanding of the structural complexity of the task and to positive feelings about it. It is usually associated with high grades.

- The achieving approach, particularly in combination with the deep approach, leads to good performance in examinations, a good academic self-concept, and to feelings of satisfaction.

Affective outcomes assessed by interviews (Marton et al, 1984) consistently reiterate that students using a surface approach feel bored, alienated, anxious or resentful, while students using a deep approach feel exhilarated, satisfied, challenged or intrigued.

Svensson (1977) found that those employing a deep approach tended to study for longer periods as the search for understanding made the work more interesting. The tedium of rote learning meant that those employing a surface approach spent less time studying.

Later research by Marland et al (1990) of distance education students' use and response to textual material concluded that students text-processing rate was much higher than the expectations of the course designer, in fact so rapid was the students processing that it seem contradictory in terms of students achieving the high-level objectives commonly associated with tertiary education. Analysis of students' thought process data showed frequent use of surface approaches.

Students were able to achieve a fast rate of text processing because they had deliberately adopted a simple, time-efficient, two phase approach; first gain an overview of the content; then read the text through once, identifying important material on the way. In-text question and activities were largely ignored in preference for assessment related material.

Moreover, Marland et al. noted that deep approach students processed text more slowly and more thoroughly than surface approach students. The progress of "deep approach" students being slowed by their commitment to goals, strategies and conceptions of learning which were more complex and qualitatively richer than those of "surface approach" students.

Watkins (1982) in a study of the relationship between approaches to studying and academic grades found that disorganized study methods, surface approach and negative attitudes to studying were consistently related to academic performance. Further studies by Kember and Harper (1986) involving distance education students concluded that surface approach or a propensity towards rote learning appeared strongly related to persistence. Students employing a surface approach were inclined to drop out, due to the tedium of constant rote-learning with limited insight into the meaning of the material.

Biggs (1989) concludes that, except for academically oriented students intent on pursuing a research degree, ordinary undergraduates drop deep and achieving approaches, alarmingly, in science more than in arts.

If the objectives of learning at the tertiary level are to be achieved a surface approach should be consistent with academic failure since students are expected to learn with understanding rather than rely on the reproduction of factual information. A predominantly deep approach to learning is the only way in which change in conceptions can occur; thus it is consistent with the general aims of tertiary studies.

However, it must be acknowledged that research findings of Biggs (1987b) and Watkins (1983) note that the effect on examination performance of an approach to learning is different for different people resulting in the overall correlations between approach and performance being fairly low. The importance for particular students may be however quite considerable.

To be consistent with the goals of tertiary education distance educators should encourage deep-level processing of the study material, and a "holistic" learning approach. The student must try to create really meaningful patterns of knowledge, based on a deep-level understanding of the text.

Thus educators would find it helpful to know what strategies deep achievers in distance education mathematics courses use and how successful in the formal sense is the use of the various approaches, and what they can do in their teaching to maximise deep, and minimise surface, approaches.

In minimizing the use of surface approach learning one needs to be aware of institutional factors which encourage or discourage its use. Kember and Harper (1987) categorized students who employed a surface approach into two categories: there are those who habitually employ a surface approach and need study skills training to develop learning styles more appropriate to tertiary education, and there is a second category of students who are capable of employing a deep approach but use a surface approach for a variety of institutionally dependent reasons.

2.4.3 FACTORS AFFECTING APPROACHES OF TERTIARY STUDENTS

Student approaches to learning have found to be fairly consistent over time but situational factors can be a strong influence. There is evidence (Entwistle and Ramsden, 1983; Kember and Harper, 1987) that students who are capable of and habitually employ a deep approach can be induced towards a surface approach by surface demands such as surface assessment demands, high workloads, over prescriptive courses or an inhospitable learning environment.

TIME

It is well acknowledged that for the majority of distance learners time is a resource which has to be used prudently in order to fulfil vocational and family obligations as well as study commitments.

There is evidence (Entwistle and Ramsden, 1983; Marland et al, 1990) that time pressure forces students to learn in a superficial manner, by attempting to memorize information rather than gain understanding of the schema underlying the information. In Marland's study of extramural students this time conservation principle was applied by the majority of students in their search for significant content, such content being defined by them as material related to assessment tasks. Wherever possible students used time-efficient tactics.

Excessive workloads in courses will also result in students, faced with a large quantity of knowledge, abandoning the search for meaning and resorting to memorizing algorithmic procedures for answering problems in order to pass examinations.

ASSESSMENT

Assignments are central to distance learning. The submission of assignments throughout the year helps students pace their studies, provides for contact with the tutor and feedback as to progress.

For some students assessment, rather than the method of teaching or clarity of the text, dominates his or her approach to learning.

> *"While it appears obvious that assessment methods should be so designed that they encourage (and test) deep approaches, the reality revealed in the studies of student learning is very different...assessment procedures provide crucial messages to students about the kinds of learning they are expected to carry out." (Biggs, 1987b, p 159)*

The design of assessment tasks in the education course reviewed in research by Marland et al (1990) is reported to have encouraged students to be selective in their readings. They concluded that the one-to-one correspondence between assessment tasks and segments of the text meant that assessment activities did not require students to re-read, integrate or synthesize material from various parts of the text.

Earlier studies into learning processes by Marton and Slajo (1976) found that students who habitually employed a deep approach had tended to adopt a surface approach in the face of persistent factual questions. However those students who habitually employed a surface approach found it difficult to adopt a deep approach when faced with meaning-orientated questions.

AGE

Distance education students are represented by a largely adult population. Studies (Biggs, 1987b; Entwistle and Ramsden, 1983; Harper and Kember, 1986) found that mature age students reported increasing use of achieving, and deep approaches. Biggs suggests that this could be due to self selection; the emotional and financial cost of taking up studies, even part time, is greater for older students, but it is also likely that they have learned something about themselves and their learning that school-leavers have not yet learned.

Adults are generally intrinsically motivated students. They are motivated to learn particular topics because their life situation has defined a need to know, or because they have developed an interest in the topic. They rarely study something because they have been told it will be important to them one day; it is already important now. Combine this intrinsic motivation with the fact that adults have a higher personal stake, both literally and in terms of their self esteem, results in mature students demonstrating a predisposition to deep and or achieving approaches to learning.

Records of mature age distance learners' progress, as compared to younger internals, show that while withdrawal rates are higher, externals who persist achieve considerably better results than younger, internal students. (Biggs & Telfer, 1987)

CONCEPTIONS OF LEARNING

The link between a person's beliefs about what learning is, and how that person will engage in a task is strong. Van Rossum and Schenk (1984) found that surface learners believed that learning means "knowing more" or memorizing. It follows that if one perceives learning to involve the accurate retention of facts the student will concentrate on the task rather than the structure. In contrast, deep learners believed that learning is associated with understanding and construction of a personal philosophy or world view.

METALEARNING

Metalearning refers to a student's awareness of and control over his or her learning process (Baird and White, 1982; Biggs and Telfer, 1987; Biggs 1987). The student is aware of both the content to be learned, and of the act of learning. The second kind of awareness is more advanced. It includes awareness of one's motives, of what the task requires and whether one can meet those requirements, of the strategies to be used once the task is confronted, and overall of how well one is doing.

Learning approaches, especially deep and achieving, are most effective when students are consciously aware of their own learning processes and try to control which strategies to select and use.

> *"Learner awareness includes awareness of the nature and process of learning, and of personal learning styles and particular deficiencies. Learner control through conscious self-evaluation and decision making expediates effective learning." (Baird and White, 1982, P 245)*

Students with good meta-learning skills demonstrate a coherent approach to learning based on their motives, and control their learning through conscious self-evaluation and decision making. In contrast students with poor meta-learning skills choose strategies that are incongruent with their motives, such as rote learning (surface strategy) to satisfy intrinsic curiosity (deep motive), or continue to learn in a particular way, regardless of evident lack of success.

There is much evidence (Biggs, 1987b) that knowledge of how one is learning, as well as what one is learning can be used increasingly as one grows older and more experienced to monitor, control and improve learning.

2.5 USE OF WORKED EXAMPLES AND EXERCISES

Worked examples, in distance education material, are the primary tool which written instruction material relies upon to teach the student how to solve problems, accompanied with a larger number of problems or exercises. Of particular interest to distance education is recent evidence showing that learning and problem solving may be facilitated more by students studying many worked examples rather than solving many problems.

The general consensus of mathematics educators is that mathematics is not a spectator sport: to learn one must be actively involved in problem solving.

> *"You will find that the textbook suggests exercises for you to try at frequent intervals. It is quite important that you work through most of these when you encounter them. They will give you practice in using techniques, test your understanding of the material you have been reading and sometimes reveal new facets on the topic you are studying." (60.102 Introduction)*

Likewise, Knight (1987) stresses that it is the active, problem-solving mode that permanent mathematical learning takes place.

> *"Managing the learning process, then, involves presenting information, linked to previous knowledge of the student, together with providing exercises which will reinforce those links and extend and refine the "cognitive map" (Skemp, 1979) which the student is using." (Knight, 1987 p 68)*

The role of problem-solving is important for the gaining of experience or filling out detail of the cognitive map, either by reinforcement or refinement of concepts in the students' existing framework.

Research focusing on how students can successfully solve problems has been especially prolific in the last few decades. Areas of interest have included related issues of:

(a) problem solving heuristics,
(b) differences between novices and experts and
(c) the interaction of learning and problem solving.

Conclusions such as from Owen and Sweller (1989) that students may learn more by solving goal-free problems or by studying their problem solutions than by solving the problem in the first place, require researchers to examine the role of conventional problem solving exercises. Further research by Ward and Sweller (1990) concludes that under some conditions, substituting worked examples for problems or exercises enhances learning and subsequent problem solving.

Chi and Bassok (1989) view the example as an essential instrument from which to learn because it instantiates the principles that the text aims to introduce.

> *"An example of a worked-out solution presents an interpretation of the principled knowledged presented in the text in terms of the procedural application." (p 265)*

Students prefer to rely on examples as a learning tool (several studies cited in Chi and Bassok, 1989; Svenson et al,1983). Moreover, empirical evidence from Zhu and Simon (1987) shows that many students can learn to solve problems by studying worked-out examples only without any background text.

The research into the role of examples in learning focuses on two aspects:

(a) how students learn from studying examples, and
(b) the structuring of effective examples for schema acquisition.

Chi and Bassok (1989) hypothesize that differences in problem solving success, from students with similar declarative knowledge, may result from differences in how students study the examples and differences in the mechanisms and techniques they use to learn the procedural instantiation of that declarative knowledge.

Examples in a text are inadequate at providing the rationales for the application of each of the procedural steps. The solution procedure depicts a sequence of actions, without providing the specifications of the inputs that will produce such a sequence of actions. Chi and Bassok argue that when students fail to generalize from an example, we should perhaps attribute the failure not to the characteristic of the example, but rather, to the disposition of the learner.

Their research into the role of students' self generated explanations, while studying physics examples, concluded that in order to optimize learning, the students must actively construct an interpretation of each action in the example. Because examples are incomplete in providing explanations, the student must necessarily construct their own explanations for the sequence of actions in order to understand the material.

In contrast if the student reads the example, learning only the sequence of actions, then they have basically acquired an algorithmic procedure, which will not readily be transferable to a related problem/application. The student, may feel confident that learning has taken place but it is of a surface nature with the student gaining very little understanding.

Chi and Bassoks' research with physics students found that good students' learning from examples was characterized by a significantly greater number elaboration ideas and self-explanations. The self-explanations of good students tended to be qualitatively better and had the characteristic of adding tacit knowledge about the actions of the example solution, thus inducing greater understanding of the principles introduced in the text. In contrast, the poor students' explanations were often paraphrasing of the diagram, with no new information generated.

The degree to which self-generated explanations foster learning is a function of the accuracy and completeness of the self explanation in interpreting the example in terms of the principles introduced in the text, thus will depend on the students initial understanding of the text or principles.

A seemingly obvious answer to the lack of explanations in worked examples is to rewrite examples containing all the justifications that are implicitly embedded between the statement lines. But if one adopts a constructivist approach in writing worked-examples it would not be possible to "supply" all the explanations for each individual student's understanding. Chi and Bassok's findings reinforce the model of learning in which the student is an active constructor of knowledge. For a good student who can generate his or her own explanations, these additional comments will be redundant. For the poor student who has little understanding, such explanations may actually confuse rather than clarify, and perhaps limit performance.

Blais, (1988) in research into differences between novices and experts processing of material, takes the position that providing students with a maximum of explanation will often serve to perpetuate the "remedial processing" of novices.

When novices read, the process almost always is directed to acquisition of specific information that will be needed for algorithmic activity, allowing them to achieve correct performance without relying on the simple understandings that result from the perception of essence. Thus novices sabotage good conventional instruction by selecting from it only the minimum necessary to achieve correct, mandated performance. Drawings, estimation, abstraction, connections to simple examples, informal explanations are viewed as unnecessary embellishments. They resist learning anything that is not part of the algorithms they depend on for success.

In contrast experts were found to direct attention to the underlying structures of the content, a characteristic of a deep learning approach.

Baath (1986) also warns of the dangers of over-supplying distance education students with information/explanation.

> *"Far too many course units are full of well-chewed and well digested, but also rather scentless and colourless, mental food. Everything is ready for the student to swallow-to read and to remember. There is no exciting intellectual challenge in the written material. In the long-run, written instruction of this kind may counteract learning rather than promote it." (P 12)*

Research by Owen and Sweller (1989) and Ward and Sweller (1990) have investigated the possible effects of worked examples being used in the acquisition of schema instead of the more traditional exercises. Evidence from many studies, Cooper and Sweller (1987), Sweller and Cooper (1985), Zhu and Simon (1987), shows that learning and problem solving can be facilitated more by students studying many worked examples rather than solving many problems.

In mathematics it is agreed that schema acquisition and rule automation are basic components of skilled problem solving performance. Possession of appropriate schemata allow expert problem solvers to recognize problems and problem states and to use a schema to generate moves from the problem state to the goal state. Rule automation frees the problem solver of the need to consider consciously the validity of rule use, and this in turn allows cognitive resources to be employed fully in searching the problem space.

Cooper and Sweller (1987) made several suggestions concerning the interaction of schema acquisition and rule automation:

a) schema are more likely to facilitate performance on problems structurally similar to previously seen problems,

b) rule automation should facilitate problem solution on all problems, but especially on transfer problems that are sufficiently different from previously encountered examples to reduce the utility of schemas,

c) schema acquisition can occur relatively quickly, whereas rule automation is a slow process requiring considerable practice.

Thus, as a consequence of these points:

> *"A procedure such as a worked examples that can facilitate learning will first improve performance on problems similar to these seen previously, due to schema acquisition. Only later will transfer improve due to rule automation." (Ward and Sweller, 1990, p 2)*

Substantial evidence, using a wide variety of problems, suggests that means-ends strategy, which is commonly employed by novices interferes with learning. Sweller (1988) theorizes that because efficient problem solving via a means-ends strategy requires a search for operators (rules) to reduce differences between problem states; this search, although efficient from a problem-solving perspective, inappropriately directs attention and imposes a heavy cognitive load that interferes with learning.

Ward and Sweller suggest that a more appropriate alternative to conventional problem solving, which although facilitating problem solutions may interfere with schema acquisition and rule automation, may be worked examples. Examples should focus attention on problem states and their associated moves thus reducing cognitive load. Consequently, they should facilitate learning and subsequent problem solving to a greater extent than actually engaging oneself in the solution process.

Further research by Sweller (1988) suggests that the format of worked examples, as an alternative to conventional problems, must be such that they appropriately direct attention and reduce cognitive load. Tarmizi and Sweller (1988), using circle geometry problems, provided evidence that, worked examples that required students to split their attention between multiple sources of information, such as a diagram and a set of statements, and mentally integrate those multiple sources were ineffective.

Ward and Sweller (1990) conducted classroom experiments using physics examples of differing formats. They concluded that although studying worked examples can be a highly effective mode of learning, the presentation format is critical.

> *"The more detail and assistance a worked example provides, the more difficult it is to format the problem with a unitary structure. Additional information intended to be helpful to students but not strictly necessary may be difficult to integrate physically with essential core information, leaving students to accomplish the integration mentally, with the deleterious effects..." (p 31)*

In summary their research concludes that practice with worked examples generally is superior to practice with conventional problems, but notes that not all worked examples are effective. Effective worked examples are those which eliminate the need for students to split their attention among multiple sources of information thus reducing cognitive load.

Both areas of research on examples use and example format reinforce the importance of examples in the learning process; a process which can be made more effective by the structure of the examples. Excessive explanatory material associated with worked example may not only be redundant, but may in fact be detrimental to the learner.

2.6 SUMMARY

Recent research on teaching and learning focuses on the learner as a constructor of knowledge. Research has broadly identified two main learning Approaches: Surface and Deep, with Biggs (1987b) adding a third category of Achieving Approach.

The learning approach a student uses is a characteristic of both the content and the context of the learning. The approach a student adopts will determine the quality of the outcome of learning in terms of factual recall, understanding and satisfaction. Metacognition is seen to be an important mediating factor in determining the individual effectiveness of an approach to a specific learning situation.

When learning from textual material the meaning on a page of mathematical writing is only partially given by the text; the rest of the meaning must be constructed by the student. Research into student used of worked examples demonstrates the importance of student self-explantation in the learning process. It is only by students constructing their individual explanations, bridging the gaps between the principles of the text and the example is knowledge constructed by the individual. The self-explanations are unique to each individual, depending on existing frameworks and levels of understandings.

3 THE RESEARCH PROCESS

3.1 THE RESEARCH METHOD

Because of the exploratory nature of this research into learning processes of distance mathematics education specific hypotheses regarding the learning approaches were not formulated prior to the study. The complexity of the learning paridigm, as described in the literature review, implies that learning processes are so influenced by context and by individual characteristics that general principles will be well hidden, if they exist at all. Consequently it is better to try to understand the learning approach by observing the process and allowing principles to emerge in the course of the research than to attempt to explain beforehand what will occur.

Shipman (1981) has pointed out that each social researcher is likely to concentrate on different aspects of a "confused reality", which is too complex to study in its entirety. A partial solution to understanding this complex reality is *triangulation of methodology*. Triangulation is broadly defined as the combination of methodologies in the study of the same phenomenon.

In many discussions in the behavioral sciences over the past few decades, the relative advantages and disadvantages of qualitative and quantitative research methods have been debated. However it is a basic tenet of this research that there is no necessary conflict between quantitative and qualitative approaches for generating and analyzing data.

The principle of triangulation suggests that a combination of qualitative and quantitative methodologies in the study of the same phenomenon will, where appropriate, be superior to either used exclusively. By providing more information the researcher is able to gain more insights into the problem, cross check insights and assure validity of qualitative research.

Below is an outline of the instruments used to gather data on approaches to learning and a discussion justifying their use.

STUDY PATTERNS DIARY

The aim of the Study Patterns Diary was to ascertain the study patterns of extramural mathematics students over a fortnightly section of work. In particular the researcher was interested in determining the amount of time students spend studying a section of work and the type and sequence of study activities they engage in.

The format of the diary was necessarily easy and quick for students to complete, in recognition of the expected busy lives of extramural students. Initially the diary was trialed with a small group of students working on Section 2 (Vectors and Lines) or 3 (Planes and Vector Cross Product). Students were invited to comment on the items and suggest areas not covered in an attempt to ensure the activities depicted those experienced by the students rather than those perceived by the researcher. An extra activity "Checking through returned assignments" was added to the final format on a student's suggestion.

All students were asked to keep a diary on forms provided (Appendix 1). The diary of work completed on Section 4, including their assignment, provided data on 3 aspects of their study:

1) Time allocation: - time of individual study sessions
   - total time of study per section
2) Organization of study time
3) Activities used in the study process, such as reading text, working through examples, completing assignments etc)

The diary required students to record every half-hour of study completed (or more suitable time interval) and categorize study sessions into one or two of 13 learning activities that had been pre-defined.

Section 4, which covered work on Vector spaces, Linear Independence, Basis and Gram-Schmidt Orthogonalisation, was selected for several reasons: firstly students would have established a routine study program and be reasonably familiar with the course structure, secondly early withdrawal students would be eliminated from the sample and thirdly, this section contains material which would be new rather than revision material, thus data would be more representative of learning processes.

Accompanying the diary was a short open-ended questionnaire (Appendix 2) providing data on student perceptions of "how they study mathematics". The objective was primarily to obtain background information which would form the basis of interviews with students attending the "on campus" course.

STUDY PROCESS QUESTIONNAIRE

In the second term students completed the Study Process Questionnaire (SPQ) devised by Biggs. (1987b) Some questionnaire items were modified slightly to accommodate use with distance learners and the specific nature of the mathematics course.

The Study Process Questionnaire is a 42 item, self report questionnaire (Appendix 3) that yields scores on three basic motives for learning and three learning strategies, and on the approaches to learning that are formed by these motives and strategies. Biggs' SPQ Manual (1987a) reports that:

> *"The SPQ is designed to assess the extent to which a tertiary student endorsed different approaches to learning and the more important motives and strategies comprising those approaches."*

Although the inventory was not designed primarily to predict academic performance, it is of interest to examine the relationship between approaches to studying and academic performance by investigating correlations between inventory subscales and examination marks.

SEMI-STRUCTURED INTERVIEWS

From the 21 students attending the August "On campus Course" ten students were interviewed: S04, S09, S12, S13, S16, S20, S26, S34, S35, S38. Three more students were later interviewed by telephone or meeting: S05, S10, S22. Systematic sampling was used to select students who exhibited a range of learning approaches, as determined by the SPQ, an example of data triangulation.

The objective of the interviews was to expand on issues raised in the SPQ, to probe students' perceptions of their learning environment and discuss their learning strategies. In particular, as a student's ability to diagnose and monitor his or her own understanding is an important predictor of mathematical achievement, the researcher was interested in assessing students' metacognitive knowledge.

The interviews were based on discussion of questions (Appendix 4) relating to studying mathematics in the extramural context, student use of course material, student approach to learning in general and to specific tasks such as working through an example, exercise or assignment.

All of the interviews used a semi-structured approach; the order and phrasing of the questions varied somewhat depending on the way in which the student answered, and exactly the same questions were not asked of every student. A preliminary analysis was made by listening to each tape recording and making full transcripts of the interviews.

JUSTIFICATION FOR CHOICE OF METHODOLOGY

In the past much research in higher education has used an input/output model with an overemphasis on the quantitative measures of learning outcomes. Much less attention has been given to the intermediate step of process. Research on the process phase of learning is concerned more with the qualitative issues such as whether students aim to understand what they read and whether their intention is relate new ideas to those previously assimilated.

Marton (1981) stressed that research into learning should be from the perspective of the learner, not from that of the teacher or even the academic researcher. The scientific study of learning from this perspective Marton calls phenomenography. The focus of the phenomenal approach is not on what or how much students know, as on how they use knowledge to interpret their reality. In an attempt to appreciate the total learning situation as perceived by the student a potentially richer and more accurate picture of the links between student learning and its context and content will result.

A triangulate interpretation reflects the phenomenon as a process that is relational and interactive. The interpretation engulfs the subject matter, incorporating all of the understanding the researcher's sources reveal about the phenomenon. (Denzin, 1988) The "reality" comes to be seen as located in the different perspectives and suppositions of the individual respondents.

Cohen & Manion (1989) recommends the use of triangulation in the following instances, all of which are applicable to the research objective:

1) when a holistic view of educational outcomes is sought,
2) where a complex phenomenon requires elucidation,
3) when a controversial aspect of education needs to be evaluated more fully,
4) in response to the multiplicity of perspectives present in a social situation.

The body of knowledge associated with approaches to studying and student learning styles, has mainly been developed through studies of students in full-time tertiary study. Kember and Harper (1987) provide a review of research into approaches to studying but note that the results have as yet had little impact on the distance education literature. Harper and Kember (1986) demonstrated that the constructs, derived form research on students in full-time study, are still relevant to the part-time distance learner. Their survey used the Approaches to Studying inventory (Entwistle and Ramsden, 1983) with slight modifications to suit local terminology and the external mode of teaching.

Marland et al (1990) calls for studies of how distance learners actually use and learn from textual materials; recommending that research be descriptive research in real-world contexts to provide the basis for development of grounded theory.

Knight et al (1990) also recommends research in mathematics distance education concern the processes involved rather than context orientation.

If adopting a constructivist view of people in researching self-directed learning it is vital to establish the respondents view of the situation.

> *"Researchers should, as far as possible, seek to elicit from respondents, and to represent as faithfully as possible, the views of self-directed learners themselves about their interests, attitudes, intentions and understandings. Moreover, since these factors are likely to be situationally variable a constructivist approach demands field-based inquiries as far as possible." (Candy, 1989, p. 104)*

In selecting research instrument a deliberate attempt was made to capitalize on the strengths of different approaches to research by including both quantitative and qualitative data.

"The use of multi-methods result in "different images of understanding thus increasing the potency of evaluation findings." (Smithe and Kliene, cited Mathison, 1988, p 13)

The SPQ (Biggs, 1987b) instrument has been trialled by independent researchers and provided good internal consistency coefficients and a good relation of scale scores to student performance.

The problem associated with the SPQ is that it is to some extent removed from the immediate reality of being a student in the natural setting. In producing questionnaire responses students are required to interpret their own behaviour and to abstract information which they judge to be relevant to the researcher's question. This constrains student experiences into a mould shaped by the researcher. Entwistle and Ramsden (1983) in their research with the Approaches Study Inventory stressed that it is important that the research methods do not undervalue the dynamic, tentative character of student learning in favour of a static, consistent view.

The quantitative data from the student Study Patterns Diary and the accompanying Questionnaire provides additional research evidence. Roberts (1986) used a similar Study Patterns Diary with a population of 300 extramural students of an Australian tertiary institution to research the hypothesis that there is a mismatch between the study patterns recommended and what happens in practice.

The interviews, providing qualitative data focusing on students' perceptions, are used both as a cross check of the questionnaires and to provide examples of students' unique experiences. The interview data assumes it is valid to consider categories of description - e.g. of different approaches to a learning task to which meaning is attributed through the learner's own perspective - as results in themselves.

"The philosophical assumption underlying this approach is the belief that human behaviour is integrally related to the context in which it occurs and that behaviour cannot be understood without knowing its meaning for its participants." (Minnis, 1985)

The range in different student's perceptions of the same context are compared to the learning approaches and study patterns. Different respondents have individual interpretations of their learning process, each of which is equally valid. It is in the seeking of explanations for divergent results that one may uncover unexpected results of unseen factors.

Additionally interviews provide an opportunity for reciprocity between researcher and researched. Lather (1986) cites evidence of the generation of "richer" data: debriefing sessions with participants provide and opportunity to look for exceptions to emerging generalizations.

The weakness of the interview method re subjective and impressionistic analysis may however be present. Descriptive research, is in principle incomplete: whatever is included in the description is always selective and cannot exhaust all that could be said about the objective, rather descriptions are selections from what could possibly be said.

Asking questions presupposes firstly that the respondent is able to articulate his or her understanding and intentions, and secondly that s/he uses words to mean the same as the researcher does. Also there is always the likelihood of obtaining the respondent's "espoused theory" rather than his or her "theory in use." Thus it is necessary to use knowledge of the typical motive, reasons, situations, conventions and knowledge of practices embedded in the language to interpret the student's world.

Mathison (1988) and Denzin (1988) suggests three frequently occurring outcomes of triangulation strategy are convergence, inconsistency and contradiction. The latter two outcomes result from data that do not conform to a single view of the phenomenon being studied. Thus the value of triangulation is not as a technological solution to a data collection and analysis problem, it is as a technique which provides more and better evidence from which the researcher can construct meaningful propositions about the phenomenon being research.

> *"All the outcomes of triangulation, convergent, inconsistent, and contradictory, need to be filtered through knowledge gleaned from the immediate data, the research context, and understandings of the larger social world." (Mathison, 1988, p16)*

Triangulation, Lather (1986) argues is in terms of Post Positivist research, an effective method for checking the credibility of data and useful in minimizing the distorting effect of personal researcher bias.

In summary, the research methods used offer an experiential, phenomenal perspective of students' learning processed in a naturalistic setting. While the primary instrument for data collection and analysis is the researcher, questionnaires, surveys and interviews are used for support. The combination of both qualitative and quantitative analysis are used to access the learner's perspective on the activities of teaching and learning with the intent of explaining, hypothesizing of theorizing about how distance learners use and learn from the materials provided to them.

4 RESULTS

4.1 INTRODUCTION

This chapter contains the findings from the Study Pattern Diary (**SPD**), Questionnaire, Study Patterns Questionnaire (**SPQ**) and interviews. As well as formal research instruments the researcher as tutor/marker for the course has used input from assignment work.

The exploratory nature of the research has resulted in the investigation of a wide range of aspects of the learning process. Results are thus presented in two main sections which are broadly defined to cover:

STUDY PATTERNS: Results Part 1

LEARNING APPROACHES: Results Part 2

The first section deals with the students' study patterns based principally on information from the Study Patterns Diary completed by respondents while working on Section 4 of the course material, with supplementary responses from interviews. Issues for discussion include:

- time allocation,
- study patterns
- use of resource material, in particular the use of worked examples and exercises,
- use of assignment material.

The second section considers student approaches to learning mathematics. Issues for discussion include:

- Approach scores and distributions,
- profiles of typical learning Approaches,
- factors affecting Approaches,
- metacognitive behaviour.

Findings for the second section are primarily based on the Study Process Questionnaire (SPQ) and interviews.

STUDY PATTERNS

4.2 STUDY PATTERNS DIARY

The diary was posted to all extramural 60.102 (Linear Algebra and Geometry) students. Included with the Diary (Appendix 1) was a short open questionnaire.(Appendix 2)

The response rate was 32 returns of the 84 enroled students which represented 31 of the 66 students completing the course. This response rate of 47% of participating students compares favourably with similar extramural surveys (Roberts, 1986). The low rate of response can probably be attributed to the reticence of many busy extramural students to maintain a diary during their valuable study periods.

4.3 TIME SPENT ON SECTION 4

There was a large range in the hours spent on studying Section 4 and completing the assignment: 5 hours to 19 hours. The majority of students spent up to 10 hours over a period of 2 to 5 days in total. Figures 2 and 3 are Bar Charts showing the time distributions for the respondents.

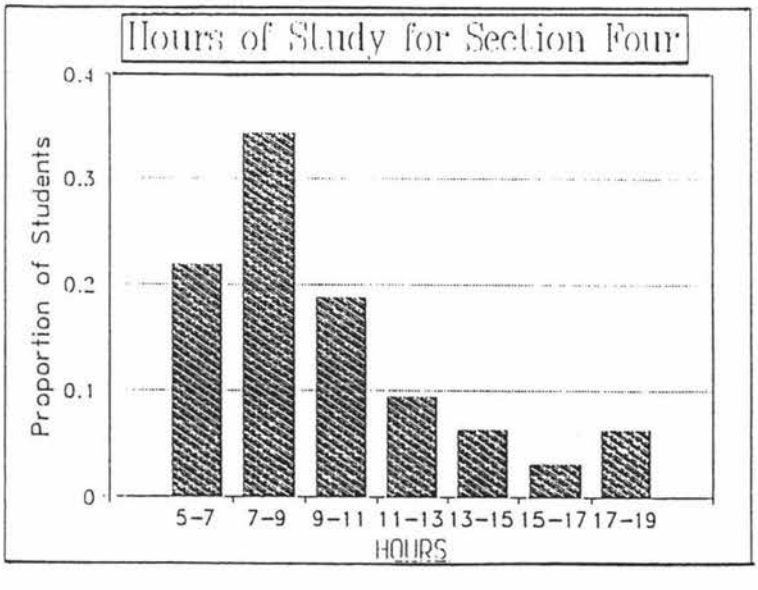


Figure 2: Hours of Study spent on Section 4

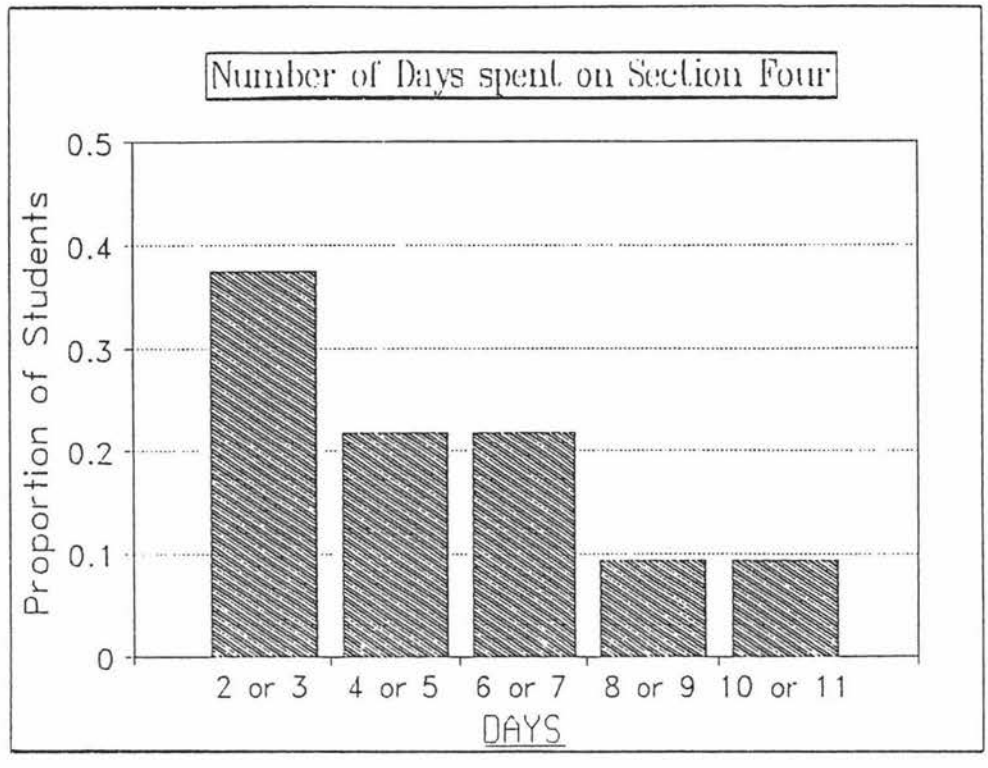


Figure 3: Days spent on Study for Section 4

In response to the questionnaire questions

"Have you done sufficient work on this section?" and

"Was the workload for this section about right?"

75% of students responded that they had given the material sufficient study time, with 41% specifically mentioning that they intended to spend more time on the section by way of revision. 25% responded that they had not done enough study on this section; several of these respondents reported difficult family circumstances or illness.

All but 2 of the respondents felt that the workload was about right; the two dissenters both reported having done insufficient study on the section.

S33 *"No, I have done insufficient work on this section. I need to press on or else I'll never complete the years work. The work load for this section is too much for me."*

S33 recorded a total of 7 hours and forty five minutes on this section spread fairly evenly over a 5 day period. The maximum time on any one day (session) was one hour and forty five minutes. Time appears to be a major constraint affecting his approach; he recorded that

> *"One answer in my assignment is clearly wrong, but no time to check - must press on the next chapter."*

S33 later withdrew from the course; clearly time constraints was a major precipitating factor.

The second dissenter (S13), spent just under nine hours on the section but spread his study over 8 days. He reported that he did not enjoy this paper and it seemed that short bursts of study was all he could tolerate. The final study session of 30 minutes duration was

> *"a bit of a pain, will finish, completed or not."*

S13 completed the course, finishing 9 assignments which were returned at less frequent interval as the year progressed.

A further discussion of the influence of time constraints on study approaches will follow in SPQ results.

4.4 STUDY PATTERNS

The overall study pattern was that of reading the text (Category 1) section by section and doing the corresponding examples and exercises (Category 2, 2a). In interviews most of the students reported having a quick flip through the chapter *"just to see what's involved"* and to see *"how long the chapter is"*.

S07 *"When I first start a chapter I look to see how long it is. I read it through trying to sort out the objective. I need to find out what are the main concepts and problems and where the chapter is going."*

About half recorded that they read the text in conjunction with note taking, underlining etc. (1a). Later in interviews, some students said that the inclusion of a full summary booklet with the course material meant note-taking was unnecessary. Several students said that they kept summary notes of worked exercises for each section; this would not have been evident in the SPD categories.

The proportion of total study time allocated to working through example and exercises (2, 2a, 2b) was difficult to determine with accuracy because the majority of students recorded reading the text in conjunction with working through exercises. All recorded spending some time on the compulsory exercises but only half the respondents recorded working through the extension exercises.

The time devoted to the assignment preparation and completion (3, 3a and sometimes 1 and/or 4) was usually between 2 and 4 hours. This accounted for, on average 35% of their study time.

70% of the respondents left the assignment questions until they had finished working through all of the section. One third reported doing the assignment independently of their notes while others referred back to previously studied material. For poorer students reference to text involved a search for a solution or template from which they could map the to-be solved problem so as to generate a solution. For the better students looking back to the text or notes was as a reference, eg.

"I need to find the formula that you use for this type of problem".

These students already had a plan for a solution in mind

It was significant that 60% of the respondents mentioned the importance of the worked examples and over 70% recorded working through examples in text (using pen and paper, 2a) as a major activity. In view of the research outlined in the literature review (Chi and Bassok, 1989; Owen and Sweller, 1989) the use of example material as part of the student's learning is discussed further in the following section.

4.5 EXAMPLES AS A SOURCE OF LEARNING

In both distance education and lecture/classroom teaching, the conventional mode of mathematics teaching is the presentation of new material followed by one or two worked examples using the new material, followed by a reasonably large number of problems or exercises.

One of the major differences of a student learning in an extramural environment, compared to an internal student attending lectures, is the reliance on the text as the sole source of information. In the initial explanatory stage of the text presentation examples are the primary tool which written instructional material relies upon to teach the student how to solve problems. An analysis of the extramural material for 60.102 shows that we have a 3 : 7 ratio of worked examples to exercises.

However there is a major difference in presentation of examples in texts to those presented in a classroom situation. In a classroom the teacher and student interact, thus steps in an example would be highlighted, questioned, paraphrased or explained. The student would have both examples of and opportunity for self explanations, which according to Chi and Bassok (1989) are so critical for effective learning.

In light of the recent research on student use of textual material one needs to examine the role of the worked example in the extramural environment. What is it that the student learns from the worked example and how does the student process the example to enable this learning to take place?

Firstly, all of the respondents cited problem solving activities involving both worked examples and recommended exercises as the most important activity in their learning process. Students spend a large amount of their time on this activity, which probably contributes substantially to their competence.

S38 *"Good worked examples are the most important part of my learning initially, otherwise I've got nothing to base my understanding of the question on. I do learn from exercises, there is no doubt about that, but I feel that people who go straight to the exercises have either a tremendous amount of confidence in their ability or are very lazy."*

As in other research studies (Zhu and Simon, 1987) students in this study reported, in both interviews and the Study Pattens Diary, a preference for the example over the textual exposition.

S20 *"The worked examples are much more important than the text, I don't always follow all the text but the examples are much easier. I work through the example."*

S04 *"I can spend a lot of time and thought on the text not getting very far; but if I use an example and work through it, it is very helpful - there are not always enough examples. I find the theory very difficult; I can't make head or tail of it until I've found enough examples to understand what it's talking about."*

Students regard the procedures that example exemplify as the major knowledged to be learnt.

S22 *"After careful reading of the text- I proceed to the first worked example. This for me is the core of the work, the practical technique I shall have to learn, If there is a second example I try and work it independently."*

Reports of students committing knowledge of worked examples to memory or recording examples in notes or course summary are an indication of the importance that students attach to the worked example.

S16 *"I often copy out the worked example working on the principle that if you write you are more likely to learn it than if you skim over it with your eyes."*

S26 *"Worked examples are very, very important. Sometimes I put them in my notes."*

The manner in which the student process the example can play a significant role in affecting what can be learnt from an example. Chi and Bassoks' research into the role of students' self generated explanations concluded that in order to optimize learning, the students must actively construct an interpretation of each action in the example in the context of the principles introduced in the text.

Examples in a text are inadequate at providing the rationales for the application of each of the procedural steps. The solution procedure depicts a sequence of actions, without providing the specifications of the inputs that will produce such a sequence of actions (VanLehn, 1986, cited Chi and Bassok).

Consider Example 4/7 from the 60.102 text "Geometry and Linear Algebra", (Thornley and Hendy, 1989).

Example 4/7

Are the vectors $\begin{bmatrix} 3 \\ 3 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$ *linearly independent?*

Write the components of the vectors in rows and use the elimination technique.

$$\begin{array}{rrrr|l} & 3 & 3 & 1 & \\ \rightarrow & 1 & -1 & 2 & -3 \\ & 0 & 1 & 1 & \\ \hline & & 6 & -5 & \\ \rightarrow & & 1 & 1 & -6 \\ \hline \rightarrow & & & -11 & \end{array}$$

No rows of zeros occur so the vectors are linearly independent.

In this example explication of the rationale underlying the sequence of actions is not given. It is not clear why one should "write the components of the vectors in rows and then use the elimination technique", nor why "no row of zeros" should imply linear independence without reference to the principles in the text.

If the student reads the example, learning only the sequence of actions, then he or she has basically acquired an algorithmic procedure, which will not readily be transferable to a related problem/application. The student, may feel confident that learning has taken place but it is of a surface nature with the student gaining very little understanding.

As with Chi and Bassoks' research with physics students, the research found that good students' learning from examples was characterized by the generation of self-explanations. Self-generated explanations relate to the content of the example by providing explanations for the action sequences. Many students reported the process of "filling in the gaps" while working through the examples.

S20 *"Sometimes I add questions and refer back to the text to fill in jumps in examples - especially on new material. It is probably very obvious to everyone else but it is difficult for me."*

Often students were aware that they must necessarily construct their own explanations for the sequence of actions in the worked example in order to understand the material. Their self-explanations had the characteristic of adding tacit knowledge about the actions of the example solution, thus inducing greater understanding of the principles introduced in the text.

S07 *"I read them and work them out mentally if they are straightforward but usually I need to add steps - ask myself how they got from one line to the next. I write down questions besides the example or put in more steps or references to other parts of the text. I assume the working is wrong until I've proved it right by working through it."*

S04 *"When working through an example I would have to turn back and find explanations. I need to make sure I understand every step; it takes a while."*

Chi and Bassoks' research found that good students generated a significantly greater number of elaboration ideas and the explanations generated by the good students tended to be qualitatively better. Their explanations demonstrated a stronger interaction between the textual material and the worked examples.

S05 *"Quite often the text doesn't make sense at first so I look at an example so I can see what the text has been saying so you go backwards and forwards between the text and the worked examples."*

Whereas the poor students' explanations were often paraphrasing of the diagram, with no new information generated. Poor students reported "rereading examples"; this is probably a consequence of the fact that very little was gained when the example was studied initially. It is not surprising, that those students who paid little or no attention to the textual exposition material were the poorer students.

An important difference which Chi and Bassok found between the good and poor students was the ability to monitor their own comprehension and misunderstanding when reviewing worked examples. A realization of comprehension failure triggers episodes of self-explanations. The fact that these self-generated explanation, by contrast to those supplied by the text, will necessarily be consistent with the students understanding, should facilitate greater understanding of the material.

> *"The advantage of having an accurate monitoring of ones understanding is that the realization that one does not understand should elicit attempts to understand." (Chi and Bassok, 1989, p243)*

This research did not explicitly explore student explanations but it did become apparent in interviews that there were significant differences in the manner in which students approached learning from examples.

When asked to work aloud an example (Example 9/3, Thornley & Hendy) in the interviews good students generated a large number of statements that reflected failure to comprehend. The content of their monitoring statements is specific.

> *" Well I cant see where they got that line from I'll need to go one step back and work out the multiplication." and "I think this is because of a theorem, but I'm not sure; I'll have to go back and look it up."*

In contrast, poor students did not realise that they misunderstood, in fact, they thought more often that they understood; this in turn affected their generation of self explanations and consequent understanding. The two interviewed students, who later failed the course, gave comments such as *"well that bits seems obvious, so I'll skip that"* and *"That example looks OK so I'll just read it through"* when in fact their was little apparent understanding.

Good students spent more time trying to work through those examples which were difficult: an active approach involving students actively constructing a solution on the basis of their individual schema. Poor students choose to ignore information that was difficult to understand and worked through those examples they thought they might succeed in; they used examples to extend what they knew rather than explore what they did not know.The following comments from S13 and S26 are representative of poorer students.

S13 *"I'm not sure what a parametric solution set is.*
I havn't a clue what all the funny hieroglyphics behind it are so I will ignore those because they don't seem to me to be part of the answer. If there's little bits I don't understand but I can still get the gist of the example that's fine."

S26 *" Sometimes I start on an example and think, "Oh I might be able to do this so I put the book aside and try and work through the example myself and then compare the working."*

Students monitoring their understanding of worked examples chose a strategy as a result of this monitoring. The majority of students read the example mentally if it was straight forward, but always worked it through with pen and paper if they were concerned about any part.

S10 *"If the examples are OK I just work through them mentally; I would write out the harder ones."*

Many of the students purposely try to work the example out on their own, some after a quick skim through, others as an initial test of understanding.

S12 *" The work examples are vital. I usually skim read the examples and then cover it up with a piece of paper and work through it myself. Most of my learning is from doing the worked examples."*

S34 *"I work examples out. Sometimes I cover them up so I cant see the final result and try and work my way through it."*

S35 *"I will work the odd example. I don't really need to do ones I'm familiar with, but some examples, especially if they are examples of proofs or algebraic examples, I will put the book upside down and work it through."*

Only one respondent reported working through every step of the examples all of the time!

S38 *"I work through the examples with pen and paper before I read all the solution. I must work them out as I can't take anything for granted."*

Students who performed better employed strategies that enabled them to gain more information from examples and concentrated their efforts in those areas where they lacked understanding. In contrast the poorer students detected relatively few problems in their understanding and used worked examples to reinforce what they already knew.

The degree to which a student's self-generated explanations foster learning is a function of the accuracy and completeness of the self explanation in interpreting the example in terms of the principles introduced in the text. The effectiveness of their learning will depend on the students initial understanding of the text and their ability to monitor their understanding.

Thus the research points to limitations in the commonly held view that a student's explanations serve the purpose of justifying an example as an instance of a principle, assuming that the student has complete knowledge about the principle. Rather results, concur with recent research (Bassok and Chi, 1989; Owen and Sweller, 1989) which demonstrate that the explanations serve the additional important function of enhancing and completing students' understanding of the principles introduced in the text.

4.6 ROLE OF ASSESSMENT MATERIAL IN THE STUDENTS STUDY PATTERNS

The SPD showed two distinct patterns concerning the attempting of the assignment questions: either students do the assignment questions parallel with studying the text or they do all of the questions after the chapter has been studied. The majority of the students (70%) reported that they did not attempt Assignment 4 questions until they had finished studying Section 4.

Students who did assignment questions in parallel always started the Section by reading through the assignment. Students using a Surface Approach previewed the assignment to identify parallel problems as they progressed through the chapter. The aim for these students appears to be "to complete as much of the assignment as possible with as little pain as possible." These students attempted few of the recommended exercises, preferring to concentrate on the assignment questions. Some students used the fact that assignment questions are ordered in the same sequence as the text material to guide them through the chapter.

S26 *"I read the assignment questions when I first looked at the chapter. I usually do the questions in parallel. The questions are usually written in the same order as the working of the text and so I know when I've got to the stage when I can answer a question."*

S13 *"I look at the assignment question at the beginning so I know where I'm going and then I read and work through text and do parallel questions in assignment. So hopefully by the time I've reached the end of the chapter I've reached the end of the assignment."*

S13 makes no mention of understanding concepts or relationships but rather he aims to "understand where the answers come from."

S27 *" I've finished a chapter when I've got the assignment done."*

Some students who opted to do assignment question in parallel with the text justified their choice as being the more efficient approach timewise but expressed doubts as to whether long term it was the most effective.

> *"I try to do assignment questions as I go along to cut back on time. Not the most effective method, so once I've caught up, I will try and leave assignment questions until the end."*

Students who leave assignment questions until the end of their study may or may not preview the assignment. Those who read the assignment questions at the beginning do so for a specific reason. They use it as a means of seeing where the chapter is heading, as one would read objectives at the beginning of a chapter, or to look at the specific problems with the purpose of recognizing parallel types as they progress through the chapter.

> *"The assignment questions were an important influence. I previewed the questions before and during studying the text so as to do my best and be aware of what the focus of my mastery and understanding should be."*

S12 *"The first thing I do is read through the problems in the assignment. My time frame is critical so I want to know what I've got to do. I've got to see what is the required result.*

S34 *"I would first of all have a look at the assignment questions, just to try and put that in the back of my mind to give me an idea of where I am going."*

S20 *"I never do the assignment until I've finished the whole study guide and then I sit down and try and do the assignment as revision."*

Some students reported that they had tried both approaches settling on the one which was more efficient.

S13 *"Usually I do assignment questions at the end - what I have done on two chapters is have the assignment questions open so I know when I get to one and I do it parallel to the text. That is probably a quicker way to do it in the sense that I'm really fresh."*

S39 *"The assignment has a lot of influence. In the first few assignments I studied the section then I read the assignment. I had forgotten how I did some of it, hence had to go back and learn again. Now I do each piece as I come to it"*

Later this same student refers to a heavy workload including two more papers thus the pressure of time seems to have determined the strategy which is most efficient for him.

Those students who consciously decided to leave the assignment until the end, felt that it provided a review of the work and was a valuable part of the learning exercise.

> *"I found I needed to check back through the steps at times, which reinforced ideas and showed the connection between the aspects taught in this chapter."*

> *"The assignment is more a way to consolidate what you've learnt in the study guide rather than a form of assessment."*

Some students reported that by not previewing the assignment questions, they increased the depth of the material studied. They reasoned that the assignment would not necessarily cover all the material and thus should not be used as a guide to which sections of the material to study.

> *"I don't look at the assignment question until after I have completed the study material, otherwise I would concentrate on the material relevant to the question and not all the study material."*

"Doing it this way I give each area equal attention. If I looked at the questions first I feel I would concentrate more on those areas I thought I might need and would perhaps not gain the same overall understanding of the topic."

Thus as a generalization one could conclude that those students who consistently completed assignment question in parallel with their study of the text were more motivated by their need to "complete the assignment" than to "study the text". In contrast students who left the assignment until the end of their study approached the assignment as an extension of their learning activity.

In the next chapter there is a further discussion of students' perception of assignments/assessment related to learning Approaches.

4.7 SUMMARY

It is evident that students exhibit many individual approaches to time organization, study programming and the use of course material. Individual differences in study patterns are consistent with Biggs' Model of Learning in which a combination of a student's motive and strategy, combined with presage factors will determine the approach to learning.

All students reported tackling Section 4 in a linear fashion, from beginning to end. Students tried examples "out" with pen and paper but very few recorded taking notes. Only a few students recorded working through all of the exercises.

Worked examples are very important to all students. Good students used examples as learning tools: by adding self-explanations they enhance and improved their understanding of the principles outlined in the text. In contrast, weaker students ignored much of the textual material, concentrating on the procedural aspects of the worked examples which would help to complete their assignments. Worked examples and the assignment questions were the most relevant sources of information to the student.

Students whose immediate goal for Section 4 was to complete the assignment, regardless of the quality of learning invariably previewed the assignment with this aim in mind. The design of the assignment questions in sequence with the text minimized their interaction with the text by enabling the students to be selective in their readings and for some to rely totally on examples for their information.

For some students this was an acceptable strategy; for others it was instigated by time pressures. For the majority of students assignments were tackled at the end of Section 4; often with reference back to notes or the text. The objective for these students was to learn the material in the section rather than principally to complete the assignment.

Thus the assignment material is a critical determinant of the study patterns either as a means to a goal, as a way of checking enough "learning" is done or as an evaluation and learning exercise.

5. LEARNING APPROACHES : RESULTS PART 2

5.1 STUDENT PROCESS QUESTIONNAIRE

In term II the Student Process Questionnaire (SPQ) was sent to all extramural students. Forty students (representing 39 of the 66 students completing the course) responded. This response rate of 60.5% is higher than that of the Study Pattern Diary, probably due in part to the fact that the SPQ was easy and quick to complete and could be completed independently of a student's study program.

As outlined in the previous Chapter, the SPQ is a 42 statement questionnaire devised by Biggs (1987b). Each item is a self-report statement of a motive or strategy (Appendix 3). The respondents rate themselves on each of the statements on a 5 point scale: 5 for "This item is always or almost always true of me.", through to 1 for "This item is never or only rarely true of me."

Biggs assumes that a student has a predilection to adopt an approach that persists over situations. The items are designed to assess the extent to which a tertiary student endorses different approaches to learning and the more important motives and strategies comprising those approaches.

The 42 items provide scores on three basic motives for learning and three learning strategies: **Surface, Deep and Achieving**. The motive and strategy scores are combined to provide data on approaches to learning. These are classified in 4 main categories: Surface, Deep, Achieving and Deep-Achieving. The items in the Student Process Questionnaire are cycled thus:

- Surface Motive (SM)
- Deep Motive (DM)
- Achieving Motive (AM)
- Surface Strategy (SS)
- Deep Strategy (DS)
- Achieving Strategy (AS)

so that every 6th item returns to a particular subscale.

To illustrate, the seven questions relating to Surface Strategy (SS) are:

4. I think browsing around is a waste of time, so I like to be told precisely what to study in the study guide.
10. I learn some mathematics by rote, copying methods with no understanding.
16. I tend to choose subjects with a lot of factual content rather than theoretical kinds of subjects.
22. I generally restrict my study to the compulsory exercises as I think it is unnecessary to do anything extra.
28. I prefer courses to be clearly structured and highly organized.
34 I find the best way for me to understand what technical terms mean is to remember the text-book definitions.
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 that rely on my own judgement.

For convenience, motive and strategy scores are referred to as subscale scores, and approach scores as scale scores. Fig 4 outlines the relationship between scale and subscale scores.

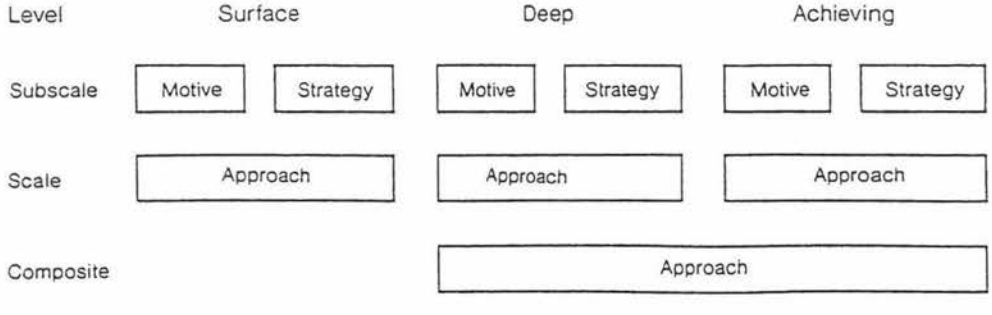


Figure 4

Composition of SPQ scale and subscale scores

Biggs (1987a) provides norms for both male and female science students (obtained from samples of about 1000 students). A full coverage of Biggs' sampling methods and discussion of reliability and validity of methods in the determination of the SPQ is provided by Biggs (1987a, 1987b).

5.2 SCORING THE STUDY PROCESS QUESTIONNAIRE

The range of scores for any one of the motive and strategy subscales is from 7 (all 1's) to 35 (all 5's). In considering an individual's score it is most useful to know how typical those scores are. Biggs (1987a) provides norm scores (based on a sample of over 1000 full time tertiary students) for male and female sudents of education, arts and science faculties.

The respondents' raw scores (Appendix 5) have been recoded according to Biggs' norm scores which reduce scale and subscale scores into a decile scale. (Appendix 6) These norm scores enable students to be placed into three categories as outlined in Table 1.

DECILE SCORES	CATEGORY	PERCENTAGE OF POPULATION
1, 2, 3	LOW (L)	30%
4, 5, 6, 7	MEDIUM (M)	40%
8, 9, 10	HIGH (H)	30%

TABLE 1

As an example of the scoring procedure, a student, code S10, has the following subscale and scale scores:

	SUBSCALE MOTIVE and STRATEGY						SCALE APPROACH SCORE			
	SM	SS	DM	DS	AM	AS	SA	DA	AA	DA
RAW	13	15	32	26	15	24	28	58	39	97
DECILE	1	1	10	9	3	7	1	10	5	8
CATEGORY	L	L	H	H	L	M	L	H	M	H

5.3 INTERPRETING THE SPQ SCORES

The scores obtained from the SPQ are useful for establishing trends re learning approaches and motive/strategy combinations, assisting in profile development of successful and unsuccessful learners and in enabling comparison of learning approaches between full-time students and different faculties.

There are limitations to the SPQ scores and consequent interpretation which must be acknowledged. Firstly, because of the sampling methods (voluntary returns) the results may contain bias towards certain disposition types of learners. Secondly, the interpretation of the scores is based on those of full-time students of Australian tertiary institutions. Specifically the respondents scores have been normed (into High, Medium, Low categories) against Science faculty students. These assumptions suggest that one must be cautious of in-depth statistical analysis: the research is to be considered as a starting point for examining trends and establishing hypotheses rather than that which tests hypotheses.

5.3.1 DISTRIBUTION OF SCORES

An examination of the distribution of approach scores suggests that respondents are more likely to have used Deep and Achieving Approaches and less likely to have used Surface Approaches in their learning. Fig 5 presents a comparison of the distributions of Approach Scores for the respondents and Science students (Biggs, 1987). Appendix 7 provides a Chi Squared analysis, showing a significantly different distribution for Deep Approach scores of the respondents to that of Biggs' science students.

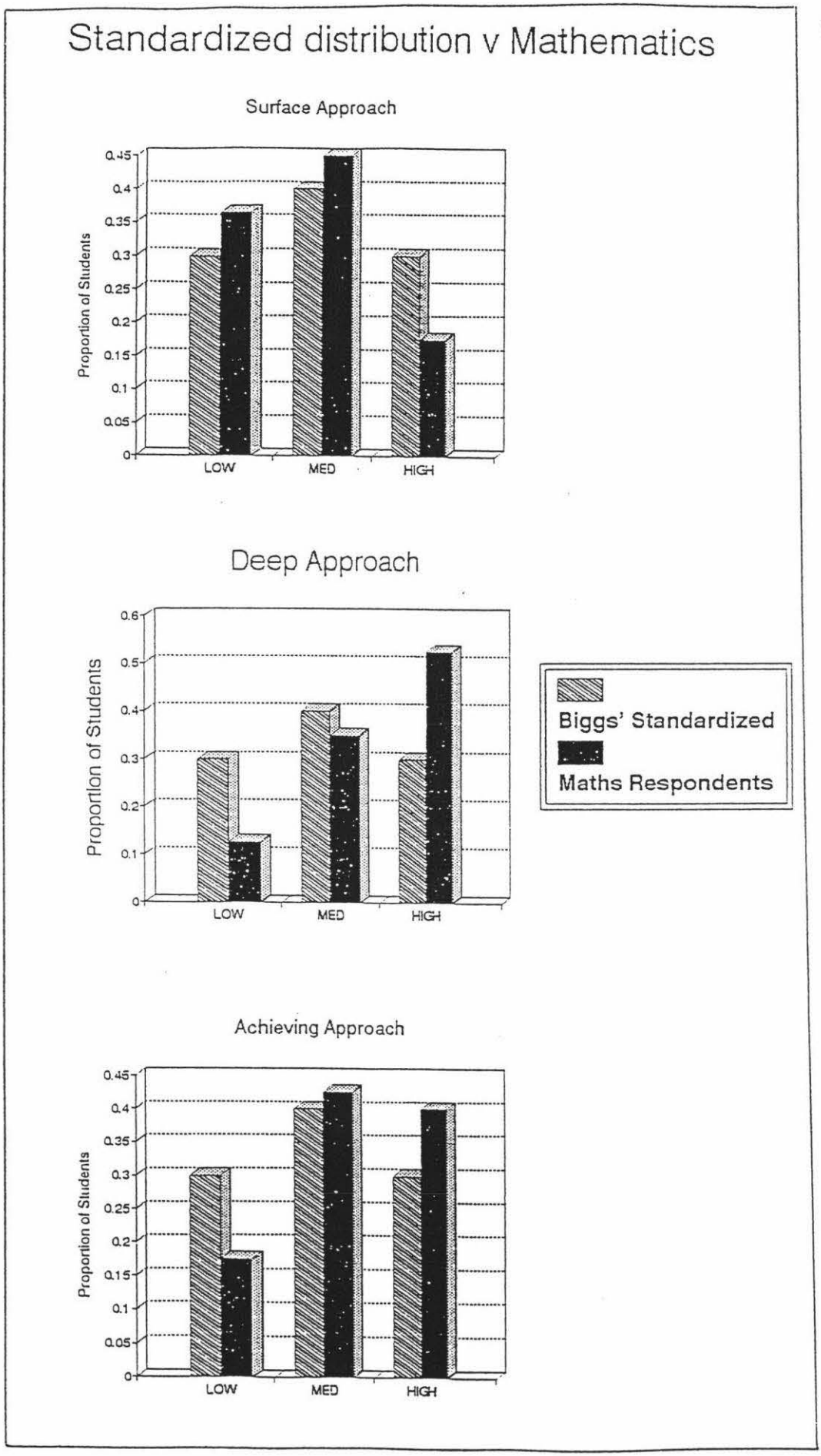


Figure 5. Distribution of Approach Scores of Science and Mathematics

A comparison between the mean Approach scores of Arts, Education and Science Faculties and the respondents' mean scores also indicate possible differing characteristics of the respondents' learning Approach Scores (Figure 6). There is a significant difference (at the 0.01% level) between the mean Approach Score of the respondent and Science students for both the Deep and Surface Approaches (Appendix 8). The high level of Deep Approach contrasts findings by Marland (1990) which found little evidence that tertiary students sought to develop broad understanding or interpretation of texts and Watkins (1986) who reported many tertiary students (Australian) rely essentially on superficial learning strategies.

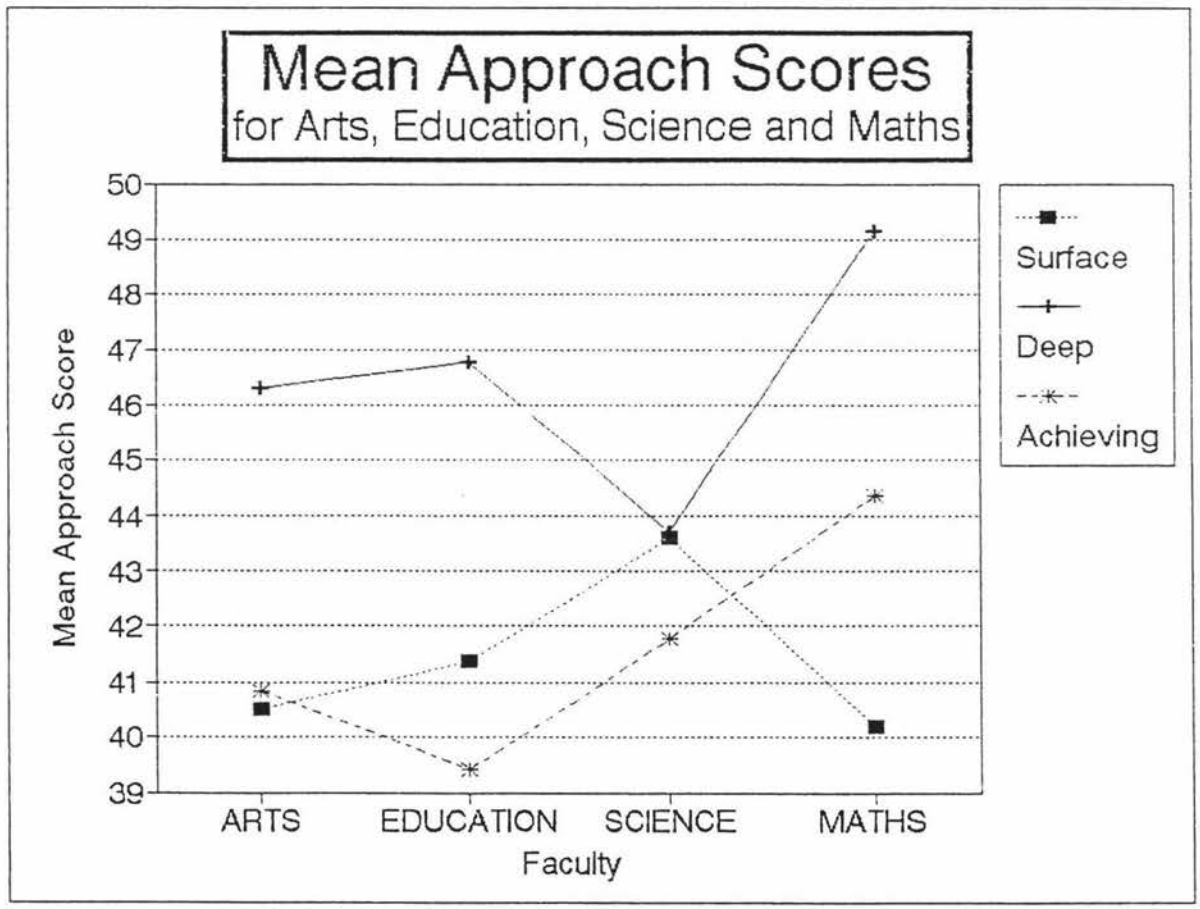


Figure 6

Mean Approach Scores for different Faculties and respondents

Without further research it is difficult to determine the cause for the apparent difference in approaches used between mathematics and science students. There are however two major differences in the research sample and that of Biggs: firstly context, a contrast of full time students and distance students, and secondly content, science in contrast to mathematics.

Thus one needs to examine, within the framework of Biggs' model of Learning, the factors which influence learning mathematics in an extramural environment. The following discussion of SPQ results includes references to the Study Pattern Diary and interviews so as to provide more information and thus gain more insight into the nature of students' approaches to learning.

5.4 APPROACH SCORES AND OUTCOME

The outcome of learning may be described in ways that parallel conceptions of learning: quantitatively, or how much was learned; qualitatively, or how well it was learned; and institutionally, or what examination mark it was accorded. (Biggs, 1989) Additionally, affective outcomes relate to how students feel about their learning.

The research did not examine specific outcomes of learning but the availability of end of year examination marks was used to examine possible relationships between approach scores and performance.

Below (Fig 8) are Box Plots relating Approach Scores to performance. As expected by Biggs' Model of Learning higher performance is associated with Deep and Achieving Approach.

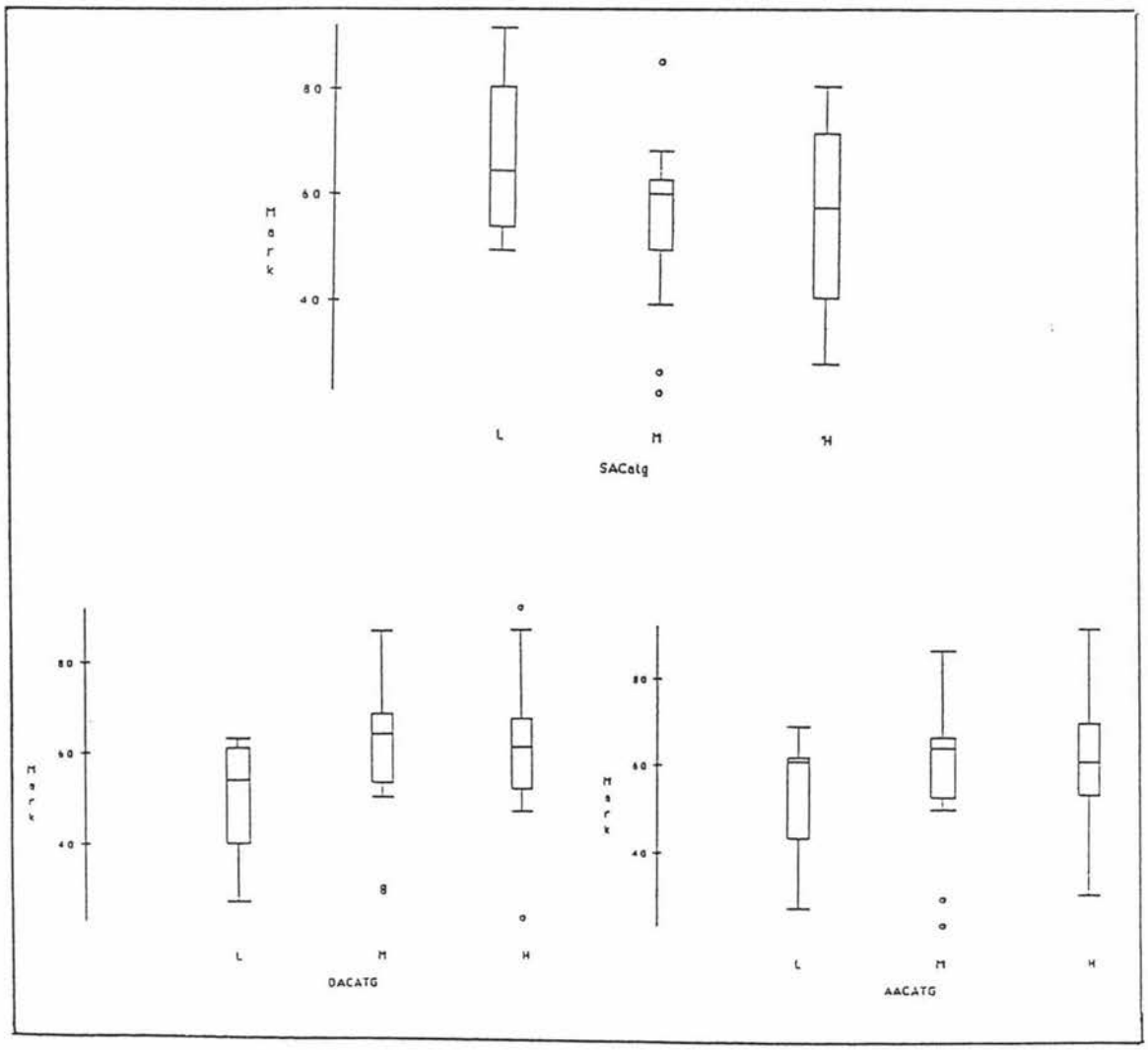


Figure 8: Approach Score versus Performance

However, the three Approach Scores show weak correlations with examination performance (Fig 9). The Surface Approach is significantly correlated (0.10%) in a negative direction with examination performance but Deep and Achieving Approach show only weak positive correlations.

Pearson Product-Moment Correlation

40 total cases of which 1 are missing

	SAppro...	DAppro...	AAppro	DAApro...	Mark
SApproach	1.000				
DApproach	-0.458**	1.000			
AAppro	0.038	0.318**	1.000		
DAAproach	-0.277	0.836	0.786	1.000	
Mark	-0.264*	0.173	0.136	0.190	1.000

** significant at the 5% level

* significant at the 10% level

Figure 9

It should be noted that the approach to learning refers to the way a student goes about a task, not directly to how well or efficiently learning is carried out. We have seen that with distance education there is a large number of interacting factors which influence the effectiveness of approaches including a student's metalearning abilities.

Biggs results are similar, although correlations were stronger: he concludes that process/outcome relationships are not always clear in the SPQ scales because it is not always certain that any given student was using the assumed "usual way of studying".

It may be that in learning mathematics a composite of Approaches is more desirable than exclusive use of Deep or Achieving Approaches. Because of the factual and procedural nature of the content a student may need to be able to used both surface Approach to focus on the facts and detail and Deep Approach to understand the procedures.

Overall students who had High Deep Approach Scores but Low Surface or Achieving Scores (Fig. 10) did not perform very well in the exam. Possibly students with a strong reliance on the Deep Approach tried too hard to understand "every bit". Quite often in mathematics understanding comes later and students need to be aware of where it is appropriate to use Surface Learning as a purposeful strategy or their learning will be "bogged down".

STUDENT	Surface Approach	Deep Approach	Achieving Approach	MARK
S26	Medium	HIGH	Low	47
S28	Medium	HIGH	Low	61
S33	Low	HIGH	Medium	27
S38	Low	HIGH	Medium	66

Figure 10

Similarly students who relied totally on Surface Approach (Fig. 11) did not generally perform well. This is a predicted result of a dependence on memorization of content with little understanding of the processed involved. The significant negative correlation verifies the predicted outcome.

STUDENT	Surface Approach	Deep Approach	Achieving Approach	MARK
S13	MEDIUM	Low	Low	40
S18	MEDIUM	Low	Low	54
S25	MEDIUM	Low	Low	57
S27	MEDIUM	Low	Low	61

Figure 11

If we examine the Approach Scores of students scoring over 75% (Fig 12) we find some consistency in that all students scored either Medium or High in Deep and Achieving Approaches; five of the seven scored HIGH in Deep-Achieving Approach, but there was no consistent pattern with Surface Approach Scores. There appears to be interactions between the learning process and individuals in that different approaches suit different people. Some approaches are likely to be harmful for some students while being beneficial to others.

STUDENT	Surface Approach	Deep Approach	Achieving Approach	Deep Achieving	MARK
S4	Low	Medium	High	HIGH	87
S7	Medium	Medium	Medium	Medium	86
S10	Low	High	Medium	HIGH	87
S11	High	Medium	High	Medium	82
S19	Low	High	High	HIGH	92
S29	High	High	High	HIGH	79
S35	Low	High	Medium	HIGH	85

Figure 12

As will be discussed in section 5.7 (Student Metacognitive Behaviour), it appears that to effectively use Deep and Achieving Approach one must have high ability and internal locus of control; that is one must be intelligent enough or inwardly orientated enough to make planning decisions about how best to study/learn and be able to monitor one's understanding. Biggs (1987b) concludes that these interactions may help explain why main effects or straight correlations between the approach and performance are small.

In conclusion, while SPQ scores appear to have some value in predicting examination performance for extramural students, individuals scores need to be examined in relation to content and context.

Some students reported difficulty in determining the meaning of particular questions in the SPQ. In particular the use of two statements in the one question was particularly confusing. For example: "I believe that society is based on competition and universities should reflect this."

Because of the significance of Learning Approach to learning outcome and the necessity to examine approaches in both the context and content of student learning it may be necessary to further explore learning inventories: Hunt (1991) has developed an Approach To Learning Inventory (ALI) which examines specific approaches used for specific content rather than overall student predilection to learning.

5.5 PRESAGE FACTORS AFFECTING LEARNING APPROACHES

Personal factors such as ability, locus of control, experience, expectations and motivations for learning predispose a student to select and use effectively a particular approach. Situational factors including course requirements, course materials and schedules also have important influences on learning approach.

5.5.1 MOTIVATION

The material and psychological cost of distance learning tend to increase with age; older students have more to give up and need to be increasingly intrinsically or achievement motivated (or both) than younger students.

An analysis of responses to the question "Why are you taking this course?" (Questionnaire and interviews) shows that students' motives fall into distinct categories:

1. **To fulfil course prerequisites/requirements or increase the range of subjects.**

This category of responses accounted for 25% of the respondents.

"I'm taking this course to increase my first year range of subjects"

"This paper is needed for 2nd year computing."

2. **I'm interested in and/or enjoy mathematics.**

This category of response accounted for 35% of the respondents.

"I'm taking mathematics more for interest sake than qualifications, which is just a bonus at the end."

3. **Mathematics knowledge needs improving to support my career or future study.**

This category of response accounted for 40% of the respondents.

> *"To improve my qualifications as a teacher of mathematics in secondary school."*

It is encouraging that 75% of the respondents either specifically refer to an interest in mathematics for its own sake or a desire to update or improve their knowledge of mathematics - usually in relation to their work in teaching.

Thus it appears that the majority of extramural students have strong intrinsic motivation (Deep Motive) or high Achievement Motivation for taking this course.

There was strong agreement between the SPQ Motive Scores and students reported motives. Comments from students rating:

- High Surface Motive included,

> *"I needed to complete my BSc to further my career in management field."*
>
> *"I am doing this paper to support my interest in computer studies."*

-High Deep Motive included,

> *"I enjoyed maths at school and now I want to broaden my interests"*

-High Achieving Motive included,

> *"personal pride in passing what I failed at another university 15 years ago."*
>
> *"This is a progression of study - from trade cert, NZCE - now a degree is the next logical step."*

5.5.2 PLANS FOR FURTHER EDUCATION

Plans for further study can be considered as long term motivational goals. Biggs' study (1987b) found that for full time tertiary students those planning to do further study scored lowest on Surface Approach, while students planning to leave after their present qualifications score highest. For Deep and Achieving Approaches those students planning to continue study scored consistently higher than those finishing.

Figure 13, a graph of mean Approach Scores for students intending to study more mathematics at a tertiary level against those who intend to finish their study of mathematics with this course, show a similar result. The most significant differences being in Surface and Deep Approach Scores.

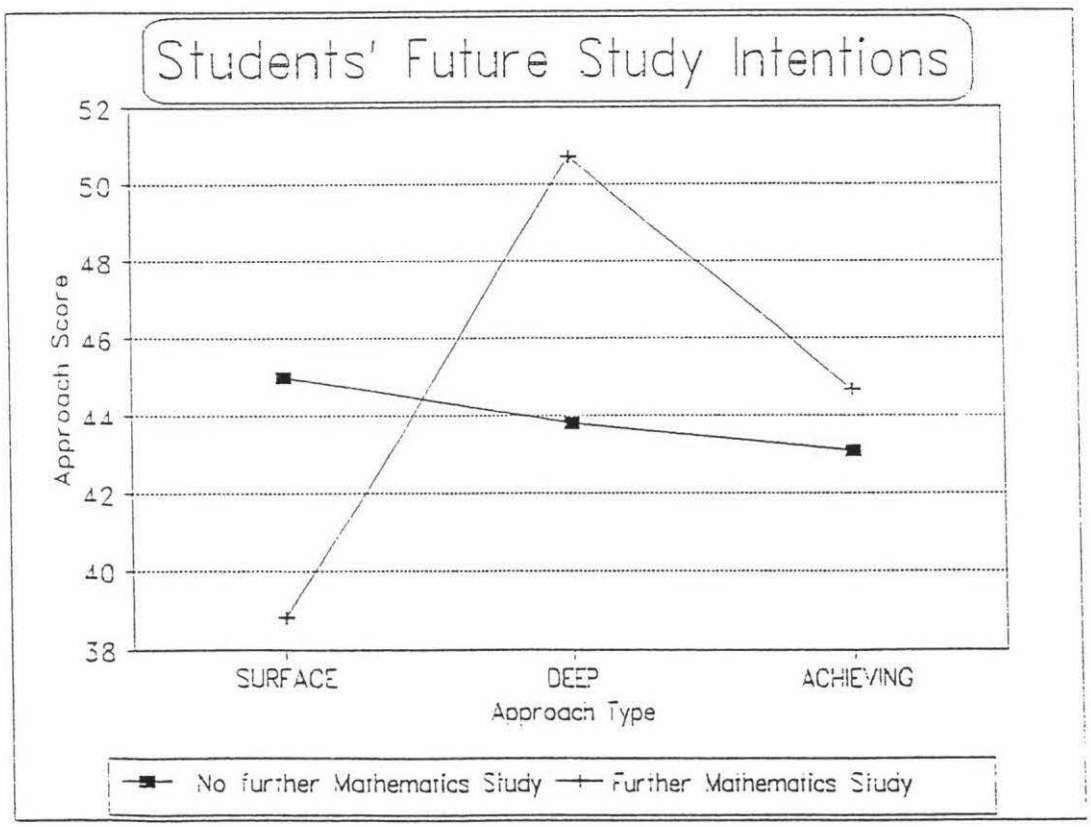


Figure 13

The pragmatically motivated student would be expected to finish at the end of the course whereas the student aspiring to further study in mathematics would expected to be both achievement orientated and employ a Deep Approach in his or her studies.

5.5.3 TIME

Distance education students often "fit" study around family and career commitments and time becomes a very valuable resource. In the Study Patterns Diary there were numerous reports of "lack of time". Similarly in the interviews "time" was reported as the most influential factor in determining a change of approach, usually from a Deep Approach to a Surface Approach.

S03 *"I do parallel assignment questions when I do the exercises, I don't see that as necessarily the best learning method. It involves compromise. I've got to finish in the time that's available, so time is a constraint."*

Some students have developed specific learning strategies to cope with the pressure of time.

S12 *"In the finite time period that I work to, if I can't initially see my way, I can't see the wood for the trees, I would just totally forget about the problem, put it right to one side and come back maybe in a days time. This time not going over calculations I had already done, I would read the question again and start totally differently and see what I could do."*

As well as having pressure to find available time in their schedule the majority of students interviewed expressed the view that learning mathematics extramurally was more time consuming than learning it internally.

S16 *" You are in a position where you are on your own and there is no tutor to help you immediately... It definitely makes the study time longer. I've spent a lot of time trying to work out how that happens or why and sometimes the penny drops and usually I get there but it takes longer."*

Availability of time for many was equated with the quality of learning. It was felt that with more time better qualitative learning could take place. One needs time to understand things.

Some students expressed the view that because you spent more time constructing your own knowledge, as opposed to having it "dished" out in a lecture you actually increased your understanding of the work in the long run.

S34 *"Its more time consuming in the long run learning from text. There are two reasons why ... firstly when you've got someone delivering the material, ie a tutor, it brings another layer that supports your learning and therefore your ability to pick up concepts both at the unconscious and conscious level- we miss that valuable personal contact. Secondly it you get into a trap, and don't know how to get out, because the information has either been assumed or incredibly obscure in the text, you have to go travelling for ages, all over the place, looking for the bit of information that you need to make the next step; but as a bonus sometimes by traversing all that different country you actually end up by picking up a whole lot of the stuff as well."*

5.5.4 AGE

Biggs reports that full/part-time status has no effect on approach, except marginally on Achieving approach, while age has a very strong affect on all scales. This may be a significant factor in the distribution of approach scores as it is well known that distance education students have a majority of "older" students.

On the motive side it has been discussed that older students are more likely to be intrisnically motivated because of experience and the personal contribution that is required to study. On the strategic side, it has been established in studies (Entwistle and Ramsden, 1983; Watkins, 1982) that strategies of wide reading and relating to one's personal experience and of organizing one's activities are more readily acquired in real life than the institution.

> *"..the further one is away from the classroom in time, the more likely one is to use these deep approaches to study, and the less likely to see study as reproducing set material" (Biggs, 1987b, p 57)*

Thus the experience that comes with maturity tends to teach older students to read widely and seek out the meaning of a topic in an organized kind of way, thus would contribute to the increased use of the Deep Approach by extramural students.

Fig 14 presents box plots showing the distribution of Surface and Deep Approach categories versus Age for the respondents of the SPQ.

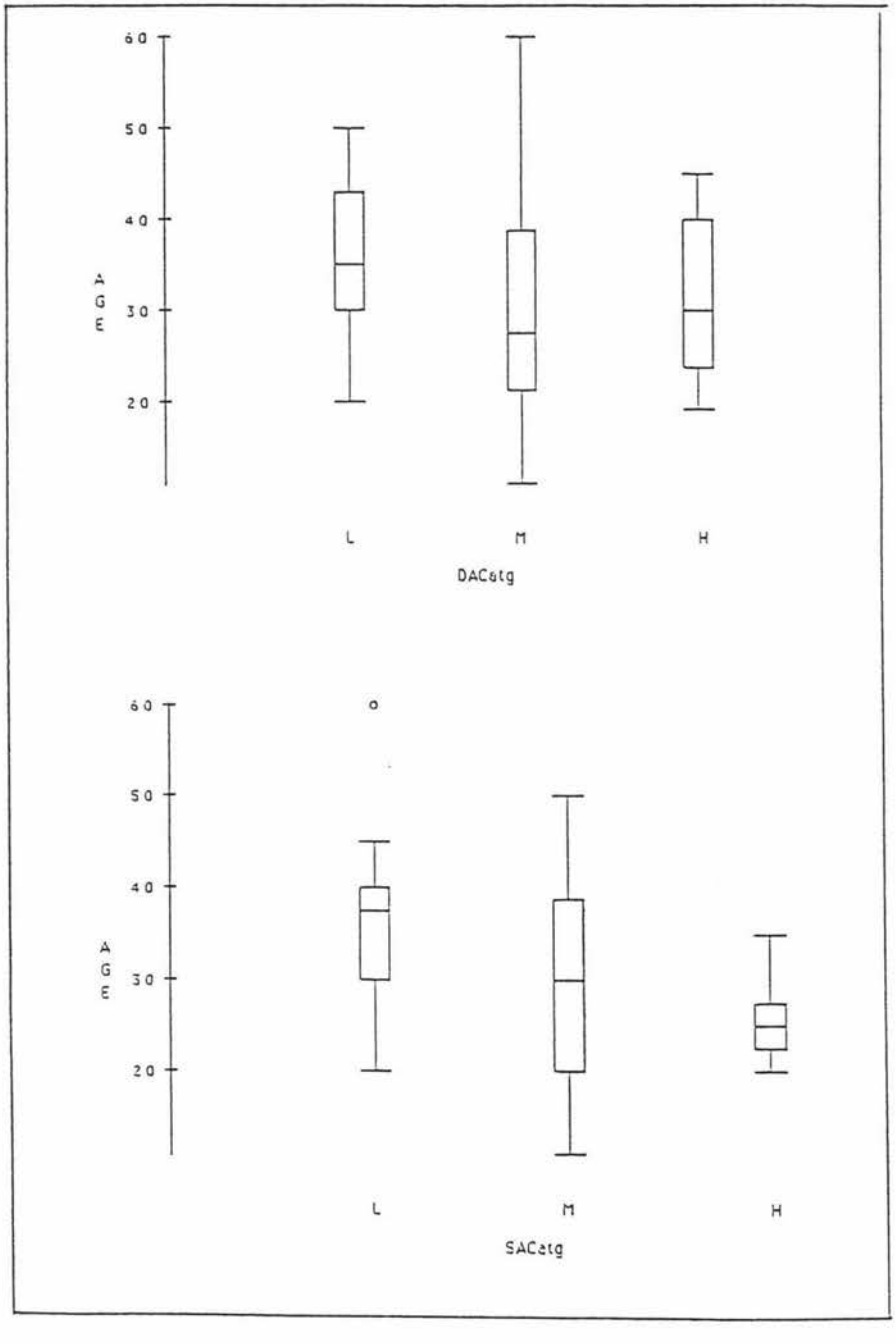


Figure 14

The respondents show a relatively even spread of Deep Approach versus age and a steady drop in Surface Approach with increased age. The expected increase usage of High Deep with increased age is not noticeable possibly because of the overall increase in Deep Approach by the respondents compared with Biggs' study. That is, the effects of learning in a distance education environment may be more significant than that of increased age.

5.5.5. PRIOR KNOWLEDGE

A learner's understanding of the text is not a straightforward interpretation of the contents of the text. Rather it is the result of a complete interplay between the content of the text and the reader's prior knowledge. Thus one can write excellent course material in its own right but failure to acknowledge the learner's prior knowledge may result in it being impossible for a student to provide appropriate schemata on which to construct new knowledge.

Many of 60.102 extramural students were returning to mathematics after a long break of 10 - 20 years. Some had bridged the gap by taking 60.103 (Methods of Mathematics) but still found the use of set notation, proof work, trigonometry, and implicit differentiation presented extra barriers. Students often reported spending an extra ordinary amount of time retrieving information to satisfy their demand for understanding and competence concerning these areas. It is quite clear that the students were only too willing to acknowledge weaknesses in their background knowledge and by supplying this extra information in the form of Appendices would have save a lot of valuable learning time and a lot of worry for many students.

Overall however the majority of the students expressed the view that the course was sympathetic to the "returning" student for the most part.

S38 *"I like the text book. It's laid out so that you can question. I say to myself "why" and keep looking until I find out why something happens. All the clues are there if you know where to look."*

5.5.6 STUDENT PERCEPTION of COURSE ORGANIZATION and ASSESSMENT

A crucial variable to approach is the students perception of what he or she is required to do - perceived tasks, attitude of tutor, department/course organization and assessment. It is important to discover what messages for the student there are in the contexts of teaching and assessment.

Assessment provides the most important single source of such messages (Biggs, 1990; Blais, 1988; Ford, 1981). The majority of students (questionnaire and interviews) perceived that the assignment was a fair and balanced form of course assessment. A minority of students felt that the assignments did not cover all the material in the section and thus concluded that assessment was unbalanced.

S01 *"I feel that some of the things we learn are missed out in the assignment, but they tend to take up a lot of the chapter."*

However, others expressed the view that the assignment questions were very appropriate specifically because they expanded on the text.

> *"Yes, it takes away some dependence on the text book style of questions and gives a wider range of applications."*
>
> *"Sometimes the questions seem an extension to the material in the text requiring extra thinking."*
>
> *"I prefer it if questions are slightly different to the examples. There should be just enough in the worked examples to lead you to the exercises. There is not much use doing exercises that are just a mirror of the examples."*

But for some this noted difference was perceived as being unfair

> *"On the whole yes but the assignment questions are hard compared to the recommended exercises. Some practice in the types of questions in the assignment would be helpful."*

One student suggested assignments should not be confined to the current section material but should include revision material.

> *"I would like them to start with some simpler questions which might serve to bring all the chapters one has covered so far, together."*

For many students the assignment was seen as the completion of their learning for a section. They perceived the process of learning as absorbing as much information as possible, usually by Surface Approach with their success being measured in terms of *"getting the assignment finished."* For these students the nature and difficulty of the assignment was a critical factor influencing their learning approach.

The majority of students perceived learning as a combination of mastering skills and acquiring facts and appreciated that the more one understood the material the more likely one was able to apply these facts in a new situation. For these students the bulk of the learning takes place before the assignment is tackled.

The assignment is treated as a test of how well the student has managed to grasp the important sections of the chapter. The student usually tackles the questions at the end of his or her work on the chapter but sometimes tries examples in parallel. If some questions prove difficult the student accepts that a section of the work was not fully understood. These students are aware of using the technique of following a similar procedure from text in a rote fashion, where necessary to complete an assignment.

There was also a group of students who perceive learning in its widest context. These students nearly always do their assignment questions at the end, often making a conscious decision not to look at question until they have finished the chapter. The student uses the assignment as assessment but also as a learning aid. They are well aware of the limitations of an assignment in that it will not necessarily cover all material needed to be learnt. They like to do a good job and will check all work and the learning that can be gained by doing assignment questions is equally as important as the actual assessment.

S38 *"I tackle the assignment at the end. I've done enough learning when I've got to the end of the chapter and the assignment is the next stage. Sometimes the assignment questions make me go back over the whole chapter."*

S12 *"I've finished the section when the assignment is done...well the aim of reading the chapter is to get the assignment done, obviously the assignments are written to cover the main points of the chapter but there is more to learning the chapter than just completing the assignments. I like to think about the total process of whats in those chapters."*

S34 *"The completion of the assignment is an indication that I've finished as much as I've for time for. I'm not pretending I've more than just scratched the surface. I see finishing the assignment as the beginning of the learning. I would like the time to think about the topic and make connections with other sections but at present it only happens occasionally. I'm starting to get an overview but I haven't got the time to fit it all together."*

S16 *"I do the assignment question at the end. The ones I've got right I know I've got right and the ones I havn't been able to do I've sometimes put additional comments by."*

Another important source of messages to the student is from the administration system, and what it rewards and punishes (Stipek, 1986, cited Biggs, 1989) refers to examples of students preferring to hand in work they know to be incorrect, because the "reward" system punishes late submission more than it punishes error. Students of 60.102 were encouraged to keep to a regular posting timetable for assignments but within this timetable individual flexibility was encouraged. While the structure of a fixed timetable was in place for those who preferred "deadlines", a large majority took advantage of the flexibility and greatly appreciated the freedom to organize their study program around personal and work commitments. Several students took a period of 3 - 6 weeks break from their study program to cope with unforseen changes in personal circumstances such as family bereavement, business trip overseas or extra commitments at work/teaching.

Overall students' perception of their course was favourable and was unlikely to encourage any inclination to Surface Approach. The majority of the students responding to the questionnaire felt that the level of the course was "about right" and the workload was appropriate. In interviews most students praised the course organization, text presentation, quick turn-around of assignments and positive, helpful feedback.

There were however, two dissenters in the interviews: S26 expressed disappointment in the lack of contact she had received with the course tutor and controller. She felt that the course should offer off campus weekend courses similar to the one she had attended for a Statistics course. S26 had failed to read written communications re course organization and ignored information as to contact support groups.

S13 reported feeling dissatisfied with the Study Guides. He felt that they were skimpy compared to those of his Calculus course, represented poor value for money and indicated little effort on the course controller's part. S13 failed to understand the role of the Study Guides as a supplement to the purpose written text, authored by the course controllers!

It is noted that these two students were the only interviewees scoring High on Surface Approach. Both students expressed dissatisfaction as to their progress and dislike for the subject content. Their obvious discontent as to course organization and feelings that they were receiving less that adequate course material, instruction and communication, would have increased the likelihood of a Surface Approach being adopted. Positive feelings are necessary if not sufficient conditions for deep learning, whereas stress and cynicism usually lead directly to surface learning (Biggs, 1989a).

5.5.7 STUDENTS' PERCEPTION OF LEARNING MATHEMATICS

As detailed in the literature review the new conception of the learner and the learning process that is emerging from cognitive research is based on qualitative understanding.

> *"Learning involves constructing one's understanding of reality - making one's own sense of other people's understanding of the world. Learning involves constructing meanings. In the process of learning in school, the learner must seek a meaningful relationship between his or her intuitive understanding of some phenomena." (West, 1988)*

Students' ideas and beliefs about their own mathematics learning and their role in that learning has a profound influence on how individuals approach learning tasks, which in turn affects outcomes of learning.

> *"It is not only the concepts about the content of mathematics which are personally constructed, and which can profoundly influence the acquisition of formal mathematics knowledge. Learners' conceptions of learning, of teaching, of assessment and so on have the same origins and influences." (Leder & Gunstone, 1990)*

The interviews explored students' perception of the process of learning mathematics: are they aware of constructing their knowledge, and in particular what role does rote learning and understanding play in their learning process.

A majority had a qualitative conception of learning, emphasising the complexity of meaning gained from their learning. For them their learning was of personal significance to themselves as individuals. These students considered understanding to be a integral part of the learning approach and were more likely to adopt Deep strategies in their learning process.

A typical pattern of learning seemed to be where a student put a lot of emphasis on the separate topics and the logical sequences connecting them, forming an overall picture of what is being learned only rather late in the process.

Students expressed the view that understanding was the desired outcome but not always totally achieved. In the Study Patterns Diary, which covered Section 4 (mainly new material), most felt that a partial understanding of the material had been achieved.

Many said that with revision or rereading they expected a consequent increase in the level of understanding. They were prepared to move on to the next section of work and expected deeper understanding to come with time, consolidation and planned revision.

> *" I'm beginning to understand it - will need to meet it and work, with it a few times. "*

> *" I think so - but will need more consolidation to be sure. "*

The students' expressed desire to re-meet work/concepts as a means of increasing understanding suggests that the provision of review sections or some revision type problem in the assignments may be appropriate. Those students whose performance was of a high level completed review test and reported specifically detailing sections, and exercises for revision.

Students strongly expressed the opinion that getting the problems in the assignment correct is desirable and a practical test of their understanding, but getting them correct by using rote learning strategies, as opposed to understanding the structure of the problem, is a sometimes necessary but uncomfortable strategy.

That it is acceptable and indeed necessary to rote learn a substantial amount of material was more acceptable for topics which were less familiar to the students prior experience. Without existing frameworks to modify and extend, students felt initially it was necessary to use rote learning (Surface Approach).

S20 *"I sometimes do assignment questions by copying examples by rote from the text, for example that's how I did assignment 4. I did quite well on it but I wasn't at all confident about it. It's very acceptable when you learn maths to use skills that you don't totally understand."*

The use of strategies that are empirically inseparable from the Surface Approach, was for the majority, seen as a stage prior to the Deep Approach. It appears that if they automate the processes/techniques then they are more able to devote cognitive processing to understanding later.

S34 *"I believe that many of the problems need to be learnt by rote first. It's like classical music - the reason why kids don't enjoy classical music in general is because they don't have sufficient exposure to the language whereas there are other musical languages which they have had exposure to simply by rote, which means that they absorb and later come to understand. I think that rote learning in the initial stages of learning maths is giving you the tools of the language on which you can base understanding later on."*

S10 *"Sometimes assignment questions, are done by using rote methods. I go back to an example and work through the exercise parallel with the example. By the time I'm finished I often understand what I've done. I do a rough copy and a good copy so I've thought about it at least twice, the good copy I don't just copy , I actually redo the working - its not rote this time."*

This use of rote learning strategies as an acceptable learning strategy, even by many students who scored High on Deep or Deep Achieving Approach might go some way to explain why the use of Surface Approach learning is similar to that of Biggs' Science students despite a significant increase, by the respondents, in the use of Deep Approach.

Some students expressed understanding in terms of achievement:

S05 *"I try to understand every step of the examples because of the way the assignment is laid out you have to understand otherwise you are not going to be able to do it."*

Several other students reported no understanding of specific sections of work but felt reasonably confident that they could handle the required problems in the assignment.

" NO, I can do it but I don't really understand it! "

Open University studies (Knight et al, 1990) found the students are perplexed about the nature of mathematical understanding. It is probable that adult students are more idealistic towards their studies than are adolescents. They want and expect to understand what they are doing, and they are disconcerted to find themselves using techniques without an overall picture of what is going on. Studies reported that even the most successful students may be tempted to withdraw from their studies because of this mis-match between their expectations and their experience.

In the research some of the older students, set themselves extremely high standards re understanding and were very reluctant to leave "bits" of the chapter unlearnt. They avoided use of rote methods where possible. Reassurance is needed in study guides that understanding often only comes when concepts are met for the second or third time.

S34 *"I would like to understand it all, but I accept that some bits will always be a bit vague - well I suppose I don't really accept it, but I've got to live with it; it leaves me very frustrated."*

S38 *"Because I've been away from maths for a long time and havn't got 7th Form I feel I've got to understand every line. I can't afford to take any bits for granted."*

For the minority of students with a quantitative conception of learning; learning had occurred when most of the material was retained with an acceptable degree of accuracy.

S13 *"There are some parts that I don't really understand; I don't want a 100% understanding...learning maths for me is a big memory thing, where you have to memorize a mass of pointless information."*

In summary respondents' perceptions of learning mathematics include:

1. total understanding is the aim but it is realistic to accept at times partial understanding,
2. understanding is not necessarily instantaneous; it may develop as a result of working through exercises/examples,
3. understanding of the material is more likely to improve by going over sections of text and exercises several times.
4. it is possible to complete assignments (usually Grade B) without having understood the section of study.

The fact that the majority of respondents expressed to some degree qualitative conceptions of learning is contrasting to findings of Borasi and Rose (1989) who expressed the generality the a large number of students in American tertiary system, seem to interpret their role as essentially acquiring facts and algorithms that can be immediately applied to the solution of given exercises; few students expected mathematics to be meaningful.

5.6 STUDENT PROFILES OF APPROACHES TO LEARNING

We have seen that while students are influenced by the demands of the learning tasks and their context they also have stable preferences for one approach or the other.

Entwistle and Ramsden (1983) concluded that what goes to make a Deep or Surface Approach in one discipline is not the same as another. Different subject areas make different demands on the types of strategies used.

The following accounts profile comments from interviews and Study Patterns Diary of students who typically use a Surface or Deep or Achieving Approach as classified by their SPQ scores.

5.6.1 SURFACE APPROACH

Of the SPQ respondents 7 reported High Surface Approach scores but none on these had a Low Deep Approach combination typical of exclusive Surface Approach.

Student (S13) results were most indicative of a reliance on Surface Approach learning. S13 Approach profile is:

SURFACE		DEEP		ACHIEVING	
SM - Low	SS-Med	DM - Low	DS - Low	AM - Low	AS - Low
MEDIUM		LOW		LOW	

S13 presented a very contrasting profile to most of the other interviewees in many aspects of his learning approach.

Firstly, in contrast to all of the other interviewees, S13 was in no doubt that he did not enjoy the course.

"I don't enjoy maths. It is a big memory thing. You have to memorize a mass of pointless information which doesn't relate to anything."

He gave his reasons for taking the course as:

"I bombed out pretty badly at maths in secondary school, it has always lurked as unfinished business. Also I am training to be a secondary teacher and learning mathematics may help me get a job."

On first glance what appears to be a personal goal for S13 is in fact externally motivated by career options and compensation for earlier academic failure. Thus the lack of intrinsic motivation and interest in the subject is replaced by an interest in qualifications and academic success.This lack of interest in the topic directly influences his study approach.

"It must affect the way that I study because the other papers, which I do enjoy, I spend that little bit of extra time with - I do extra reading and talk about the subject with other people."

His approach to using the text is directed by the Study Guide and assignment questions. He prefers the study Guide to be explicit in defining the learning tasks.

"First I read the Study Guide directions then I look at the assignment questions so I know where I'm going, then I read the text doing the parallel questions as they occur in the assignment...I would like to see the Study Guide elaborated a bit. I'm paying for the course. I sometimes feel a little cheated when I'm told "here is the text book, it's up to you now" - it doesn't seem quite fair."

When working through the text his learning focused on factual details which seemed unrelated and memorization or rote learning was his main learning strategy. He is quite prepared to gloss over topics with little or no thinking. He just reads the notes and hopes it will all "sink" in.

"If I'm not vaguely clear I will rework the example. If I have some doubts I would try and work it out otherwise I would just carry on."

When asked, in the interview, to work aloud an example he was quick to dismiss anything that was not understood.

"I'm not sure what a parametric solution set is - I havent a clue what all the funny hieroglyphics behind it are so I will ignore those because they don't seem to be part of the answer. If there is little bits I don't understand but I can still get the gist of the example that's fine - I would be quite happy with 80% understanding , I'm certainly not after 100%."

One notices as the interview progresses that he is constantly gearing his learning strategies to achieving answers; getting the problem right corresponds to his definition of understanding and is certainly the main driving force in his learning.

"Sometimes I'll do one or two of the questions to make sure I'm on track. Hopefully be the time I've reached the end of the chapter I've reached the end of the assignment. The main method is to replicate examples, that to me is the essence of my maths".

S13 makes considerable use of worked examples and the knowledge that most of the assignment questions will be similar to examples in the text.

"Worked examples are very important, I could take away a lot of the text, I can't understand it any way, as my mathematical vocabulary is too weak. I just don't have the time to work out the symbols."

A Surface Approach student is the most susceptible to situational pressures. S13 discussed time pressure and other study commitments as reasons for not attempting to *"go for full understanding"*. These personally imposed constraints seem acceptable in providing an "out" for performance.

"I don't study on a regular basis but this is not a problem for me - I do what I can, when I can."

Probably his dislike for the content and his method of learning by memorization accounts for study periods being sporadic and of a duration of less than one hour periods.

Within the Surface Approach Category Biggs further categorizes specific learning types and S13's score is representative of a Low Achiever. Specifically a low Achiever has low achievement motivation combined with a Surface Approach, thus the motive to avoid failure (SM) is stronger than the need to achieve success (AM). The low achiever has little in the way of strategic strength.

A characteristic of the learner is that of avoidance; they tell themselves that the task is either impossibly difficult or ridiculously easy and so rationalize their way out of doing anything. As the year progressed S13 seemed to exhibit these characteristics. Assignments 6, 7 and 8 were sent in draft form, asking for comments and hints, possibly as a way of avoiding the learning tasks. The last three assignments were not posted.

When asked about how he copes with difficulties in assignment work, S13 replied:

"If I'm stuck with a problem I will make an honest attempt. I will go back to the section in the text - maybe work through it a couple of times, try and get an answer. I may try and look for an alternative solution. If it's really that bad I say that's my 20% failure and accept that I haven't mastered that."

In the interviews he appeared somewhat vague about the benefits of doing exercises.

"If I'm really confident I do maybe one or two just to prove it to myself. If I really struggle I do none. I don't learn from doing exercises - learning is from reading the examples in the text. Any exercise is done just to confirm or deny that I've got the method. If I can't do it, it's not much help. I choose to do the ones with full worked solutions so they are like examples.

In summary S13's learning approach is typical of a surface approach. Motivation is external - towards the task and its requirements, and implies a process of learning in which foreign material is to be impressed on the memory for a limited period and with the specific intention of satisfying external demands.
There is no indication that the mathematics will become a continuing part of S13's cognitive structure - that is there is no evidence of any active construction of frameworks by the learner.

He lacks any strategies that would enhance understanding preferring to rely on that of reading the notes and hoping it sinks in. This approach is totally reliant on memorizing vague generalities and unrelated facts, the motivation to learn is completion of assignments. Eventually faced with an overwhelming number of procedures to be memorized and a growing dislike of the course where the knowledge is seen as a source of anxiety, not part of one self, S13 becomes a non participant. He did complete his examination, receiving a course mark of 40%.

While it is acknowledged that a Surface Approach can be used to enhance performance when a high factual recall is desired there appears to be no long term advantages to using this approach in learning mathematics.

5.6.2 DEEP APPROACH

Fifty two percent of the respondents in the SPQ scored High in Deep Approach and of those interviewed students S09, S10, S35 and S38 fit Biggs' classification of predominantly Deep Approach learners.

The combination of High Deep with a Medium Achieving Approach ensures that both their personal and institutional goals are considered, resulting in an expected high examination performance. These students scored 68, 87, 85 and 66 respectively.

All stated that their motivation was to further knowledge in a subject that they are interested in and enjoy. Their motivation is internal - to the content of the task, and to the knowledge, experience and interest of the learner, thus they are interested in learning for learning sake.

S35 *"The biggest thing that I enjoy is taking information from the text and Study Guide and adding a lot of thought then seeing something that is a real problem become clear - it can make my day."*

Entwistle and Ramsden (1983) in a discussion of the Deep Approach in science, noted that there was considerable emphasis on details and procedures, which may require a preliminary stage of rote learning which is difficult to distinguish from a Surface Approach.

I found little evidence of the above four respondents endorsing the use of rote learning. In contrast, S38 insists that nothing can be "taken for granted" and endeavours to understand everything possible. S35 admits to occasional rote learning but only if all other methods fail. S07 says that he would never copy a rote method, preferring to put comments/queries to the marker.

Characteristic of Deep Approach learning all students placed a lot of emphasis on understanding their work.

S10 *"You've got to understand all the examples - why you go from step A to step B and what is the logic behind it."*

S22 *"I try to get an intuitive grasp of the material. Otherwise you will feel insecure. Nor is it very satisfying to follow a method blindly."*

All of the students are very thorough in their learning, trying to get an overall picture of the course as well as mastering every example. They try to connect what is known about another problem or topic to the new task, looking for meaning.

S09 *"First I read the chapter through trying to sort out the main objectives. I need to find out what are the main concepts and where the chapter is going."*

S07 *"I read the text thoroughly and question every concept, thinking how it relates to what I've already learnt, making notes referencing back to earlier sections."*

However an overall impression gained from my teaching of the extramural "campus" course was that despite students Deep learning approach there was considerable difficulty for students to see relationships between topics.

Typically Deep learners are not afraid of hard work: there is no mention of shortcuts or pressure of time causing compromise in approach. They consistently express a sense of purpose in their study and interact critically with what they are learning.

S10 *"If I got stuck on an exercise I would go back and work through the examples again because then I had a clear idea of what I was expected to do."*

S10 *"It is important to do every single exercise. Practice is essential to consolidate the understanding of the theory. I could have read the whole text book in a week and understood all the logic but there is no way that I could have said I have a real understanding of the topic without doing the exercises."*

They are able to talk fluently about the process of learning, as if it had been reflected on before the interview.

S35 *"I think I learn most from the work I do because I experience it. I think I learn most from making mistakes. If you breeze through a problem there is not much learning but if you stumble you can think: now how do I do this step, what have I done wrong here, was this assumption correct and so on. Then I learn something."*

It should be noted that effective use of a Deep and or Achieving Approach requires either high ability, or an internal locus of control. S26 scored High Deep Approach but in the interview revealed a lack of internal locus of control and relatively weak prior knowledge.

S26 *"I'm not putting enough work in. I began working on an assignment when it was due in a week ago. I find it so easy just to leave study for a couple of weeks and not go anywhere near the text book. It may be easier if there were lectures. I suppose I should do more work."*

Thus, although S26 may have the inclination to Deep Approach she is not inwardly motivated enough to make planning decisions required for self directed learning.

In summary, these Deep Appraoch students exhibited characteristically deep approach strategies and motives. Their resulting learning was of a high standard as was their expressed enjoyment and personal satisfaction.

5.6.3 ACHIEVING APPROACH

Several of the interviewees scored High on Achieving Approach, most in conjunction with a Deep Approach. S04 is, according to Biggs' categorization, using a predominantly Achieving Approach. A typical student in this category is mainly interested in getting good marks. They are deliberate, careful in planning, make the best use of time and working space and ambitious.

S04 *"I was a miserable failure of maths in the 6th form and I never really accepted it as being my fault - I did do quite well in the 5th form. I find that not having much of a maths background, to get something out gives me such a massive buzz - I would keep on doing it whether it was for career purposes or not. To find you can actually do something is neat, I'm really doing it now for a challenge."*

S04 is very aware of his study strategies. He has developed an approach which gives him a feeling of success and achievement as well as striving for a desired level of understanding. His study programme is organized, resulting in a feeling of satisfaction.

"I read the text until I don't understand what I'm reading then I read it again. I have a pencil and paper and I go through it line by line. If I can follow the examples by reading that's fine but if I come to something I cant understand I write it all out and try to do it. I often go through the proofs a lot of times but quite often I don't understand them. You don't have to understand every word...I highlight things that I don't understand so I can go over them later...I have found it useful to keep all the exercises I've done to refer back to."

S04 has analyzed what the course requires of him and is very clear as to what is required to fulfil his motives.

"I know I've learnt the topic when I can hold it all clearly in my head and know exactly what's going on without having to look something up again. When I do the assignment I usually look at the first one and find a similar example - although assignment questions are usually designed so that you have to do a bit of extra thinking."

Understanding is viewed as important to learning but S04 is realistic about his expectations.

"I sometimes hand in work which I don't really understand but I still know it is right. My understanding is shaky on a lot of topics; I would like it to be more because I know in an exam you have to understand what you are doing or you can't see the shortcuts. I find that revision helps. I always try and understand as much of the text as I can bit by bit, but always look for examples and exercises to help out."

The above comments indicate developed metacognitive awareness and also strong motive/strategy congruence. S04 earned a mark of 54% in the final examination, reflective of the fact that understanding was limited in many topics. A major consequence of S04's achieving Approach was his obvious enjoyment obtained by success in the course work and in mastering mathematics in general. Because of his prior background passing a tertiary mathematics paper was a credible performance which added to his self esteem.

5.6.4 DEEP ACHIEVING APPROACH

These students combine the virtues of the Deep and Achieving approach. They exhibit an interested search for meaning and personal relevance with a carefully organized and syllabus oriented strategy to achieve high examation marks. Among the interviewees three are classified as Deep Achievers (S05, S12 and S22).Their marks of 58, 50, and 67 respectively are not representative of the high marks predicted by Biggs research.

An examination of both S05's and S12's interviews shows little evidence of their reported Deep Approach. Both respondents seem preoccupied with "getting the assignment done" and little mention is made of understanding, especially in the wider spectrum of relating topics to form an overall picture of the text/course.

S05 *"I skim through the chapter pretty quickly to see what its all about, then I go back to the beginning and start working my way through it by doing the problems of each little section. I work through the examples that the book gives and then go through the exercise. I try and do most of the exercises and then start the assignment and do all those questions and go back and check."*

S12 *"I am enjoying the course and think the presentation is great. I like to do 3 or 4 assignments at once - that's because I get started on one and can't stop... my learning strategy is basically if you have got an objective, in other words you've got a certain thing to do - read the material very quickly to see what you have got to do, get a brief look at where you are going, which path you have to go down; it doesn't matter if you don't understand it, and from then on fight your way through the examples and do as many exercises as you want to."*

The Deep Achieving Approach requires a prior knowledge and intrinsic motivation, students do not suddenly acquire knowledge about, or interest in a topic simply because a situation demands it. It is on the other hand fairly easy to switch into a Surface Approach if interest wanes, or one is tired or if there is pressure to get the task finished. Both S05 and S12 often referred to time pressures. S12 was taking six other extramural papers and organization and completion of assignments became his top priority, thus his reported Deep Achieving Strategy may have been a desired approach but external constraints severely limited the use of a Deep Approach, and consequently may have accounted for his lower than expected mark.

S10, on the otherhand talked quite a bit about understanding concepts in mathematics as a desirable outcome but was unable to discuss any appropriate learning strategies to achieve his goal. Thus the Deep motive was present but poor metacognitive skill meant a lack of awareness as to appropriate strategies.

S22 obtained the highest score in the Deep Approach category and the lowest score in the Surface Approach category of the forty SPQ respondents. Indeed his background was unique in the sample - he is a professional academic in languages and a Deep Achieving approach is consistent with a successful student in the Arts faculty.

He lacked interest in mathematics for its own sake but compensated with his interest in learning as a means of self improvement via broadening one's knowledge base. He was very aware of his motives for taking the course. There was a noticeable consistency of motive/strategy in his learning approach.

> *"I want to prove that I can learn a subject different to my professional academic area and being in an academic environment need to put in a reasonably credible performance."*

MASSEY UNIVERSITY
LIBRARY

S22's work was highly organised to fit around his work timetable and he was articulate on his learning strategies. He began each chapter by considering its length, its apparent difficulty and an overview of content. He followed a consistent pattern in tackling each section.

> *"The first reading is to get an overall picture. The second reading is to fill in the gaps and complete the picture and the third reading is to complete the exercises, check that all is understood and complete a two page summary consisting of worked examples clarifying each main point."*

Typical of an Achieving approach is a feeling of satisfaction that one is doing one's best in the given situation. It seems that learning mathematics in an external mode was very compatible with his learning approach.

> *"I learn better from written explanations than oral. I like to be able to go over the material at my own speed, and be able to repeat the material if necessary."*

5.7 METACOGNITIVE BEHAVIOUR

5.7.1 INTRODUCTION

Good students utilizing any approach do so by becoming metacognitively aware of their own learning processes. Formulating intentions, ways of realizing those intentions, and deciding what are likely to be the most effective strategies in the circumstances, are activities that would produce congruent motive/strategy decisions.

The extent to which students are behaving metacognitively is reflected in the congruence of the strategies they choose with their motivational state. It can be seen that with the SPQ scores the Surface and Deep motive score correlates more highly with its cognate strategy. (Appendix 9, Fig. 15) Thus motive/strategy form a psychologically meaningful composite for both the Surface and the Deep Approach. There was no significant correlation between the Achieving Motive and Strategy scores.

Biggs (1987b) suggests that the effectiveness of the congruent motive-strategy combination appears to be associated with the metacognitive sophistication of the student. Upon dividing the respondents into Low (<60) and High (>60) performance groups we find little change in correlation between motive and strategy scores for the High performance group. (Appendix 9, Fig.16) The SPQ indicates a similar congruence in Motive/Strategy Scores for both Low and High performers.

5.7.2 EXAMPLES OF METACOGNITVE BEHAVIOUR

Interviews were analyzed to examine student awareness of their motives and to ascertain how much control of their strategy selection and deployment students reported.

Most respondents were able to state clearly their goals and expectations of the course. An example of this metacognitive activity is a personal study contract that a student makes with his or herself. The contract recognizes the intentions and the purposes held on enrolling for a course and the actions one is thereby committed to if those intentions are to be realized (allowing for revision as experience modifies both what is desirable and what is practical).

S04 stated his personal contract:

> *"I was a miserable failure at maths in the 6th form and I never really accepted it as being my fault, I've started teaching mathematics in the primary school and am really enjoying it. I know it is hard returning to maths but I want to succeed this time."*

S38 summed up her personal contract as:

> *" I haven't done maths for 25 years. I want to get a sound base. I need to put in a lot of background work, organize my study into set times and be prepared to ask for help."*

Similarly S16 reports that to succeed:

> *"I have to be prepared to devote time on a regular basis -at least something everyday. I have to do that to make progress. I have to work hard and put a lot of hours into each assignment."*

To make a study contract that has a reasonable chance of succeeding, one needs to be aware of ones own abilities in relation to the situational context. Each of these students understood their goals and motivating force and knew what was required to achieve them.

Students, whose motive was principally to gain a qualification and not intending to further their study of mathematics were sometimes aware that they had a surface motive. Several students stated that they were not aiming for a 100% performance and so justified instances of rote learning: they were aware that this strategy would result in factual recall only and would consequently limit their performance.

Several of the withdrawals during the year demonstrated an awareness of the situational constraints in relation to the student's objective. S33, who was achieving consistently A grades, withdrew because of pressure of time. One presumes that he could have reduced his work load considerably and still obtained a reasonable pass, but was not prepared to compromise his learning approach or commitment to excellence.

Having faced the question of what they wanted to achieve by doing the course students with good metacognitive skills would then consider such questions as "what resources do I have at my disposal, what knowledge is needed and do I have sufficient for handling the course?" Many obtained reference books and/or made contact with an advisor and know where to go to find relevant help if necessary.

More specifically, metacognitively aware students need to be able to evaluate their abilities to handle the course, assessing their own relevant strength and weaknesses, whether they be in experience or abilities. For example, knowledge of ones limitations of short-term memory capacity, how one uses stored knowledge, how much rehersal or practice one needs for mastery and what strategies one has available are all part of self knowlege of cognitive skills. Accurate self knowledge of one's cognitive resources in relation to task demands is critical in developing a strategy; over and under estimation of what one is capable of doing distorts metalearning decisions.

S38 *"I learn better when listening and watching someone - that's why it is important to me to come to the campus course. The little points that I miss on become obvious when I can see someone doing it."*

S16 *"I often write things out, working on the principle that if you write you are more likely to learn it than if you skim over it with your eyes... it assists in the memory process."*

Monitoring one's learning by asking such questions as "How am I doing so far?" shows evidence of metacognitive behaviour. While the task is being performed is it necessary to continually check provisional outcomes with goals and strategies. Many students reported reviewing their strategies in light of their expectations and performance.

S35 *"I tend to try problems one at a time because I found in the early chapters that when I tried to do a whole set of exercises that I had started with the wrong assumption for the first question and then it filters through to the later questions."*

S10 *"I started by doing the assignment questions in parallel with the text. I don't think that was a good idea. I think now that it is much more sensible to do them at the end and use the assignment work for revision and consolidation."*

Students reported conscious use of control strategies to check or enhance their learning processes. An example of monitoring their understanding is when they read an example only if they are sure they understand but when in doubt they have a go at the example themselves.

S34 *"I read the text and look at the examples. Sometimes they have talked about something, then they give and example and then they solve it; often I will solve it first and then look at the solution. But if the information beforehand has been really obscure I go through the whole example and then come back and try and solve it again. My approach depends on how well I think I am understanding the work."*

Better students reported more learning occurred when the going got tough - they demonstrated and awareness of their ability to learn from their mistakes.

S35 *"Usually I find I will learn from mistakes. If I make mistakes I'll go back and say "well what have I done here?"...If I find that I go through the exercises with a breeze then when I come back to it later I often think, if I'm not in the same channel of thinking, "how did I do this". But if I've actually stumbled then I can come back to say "yes, I remember how I got over that and I remember that step", because I had to construct the meaning the first time."*

Most students are aware of the importance of making notes, writing summaries, sticking to a regular plan and doing lots of examples/exercises.

S07 *"I've learnt a chapter if I understand the concepts but I worry that I'll forget things so I make a lot of notes for later revision.... I check my understanding by making sure I've read the text thoroughly and questioned every concept, thinking about how it relates to what I've already learnt, making notes referencing back to earlier sections."*

S38 *"I would advise extramural students to try and have an organized time for study and be prepared to ask for help."*

Student need to assess their progress against their goals and decide if the end stage in their learning has been reached or has not been reached, but is good enough as far as the student is concerned. For the majority, they considered that their learning of each section was finished when the assignment was completed.

S26 *"When I've finished the assignment of course!"*

A smaller group of students measured the completion of a section in terms of overall understanding, of which the assignment was one part of assessing this.

S20 *"If I'm getting the exercises at the end of the topic right without and*

S20 *"If I'm getting the exercises at the end of the topic right without any trouble then I've done enough learning."*

S04 *"I know I've learnt it when I can hold it all clearly in my head and know exactly what's going on without having to look something up again."*

S38 *"I don't actually ever feel I know the whole topic because there is quite often questions formulating in the brain and I don't realize them all at once. Sometimes new questions come out when you do the assignment questions. I don't claim to know everything."*

Not all students demonstrated a high level of metacognitive skills. S01's SPQ score indicates incongruent approaches: he records both high Deep and Surface approach scores. This incompatibility is likely to result in wide reading, producing more data than the surface strategy can handle. The resulting poor performance mark of 30% was not unexpected.

Surface Approach learners concentrate on getting the answer right with little reflection on the process, exploration of methods, or consideration of alternative methods. Because of their lack of questioning about their learning strategies they were unable to evaluate the efficiencies of their performance or monitor their understanding. Thus it was not uncommon for them to report spending ages doing a section with little apparent evidence of learning.

Typically students with poor metacognitive skills showed little evidence of organizing study programmes or long term planning.

S13 *"I don't study on a regular basis...I do what I can when I can."*

These learners are often unaware of their deficiencies and this lack of awareness generates inappropriate attitudes. If learners are relatively unaware of their learning style they are not able to critically evaluate their approach and study methods. S13 demonstrates a lack of correspondence between perceived and actual levels of understanding and performance. He discusses concepts which are important for independent learning: being honest with oneself, making honest attempts, and self discipline and estimates his understanding of the content to be about 80%. However there was little evidence of his perceived style of learning and understanding in his reported learning strategies. His learning was of a typically Surface Approach, his study program disorganized and his resulting understanding was poor.

In marking assignments it was noted that some students failed to check their solutions and there were a significant number of students who did not understand the checking process. In these cases students were at a loss as to what to do when a check failed. They had correctly performed the check as suggested by the text (eg. Back substitution into original equations) but had not understood the purpose of the check. When the check indicated an error in their working they attributed the failure to "The problem is impossible or there is a misprint in the book" .

5.7.3 LEVEL OF METACOGNITIVE BEHAVIOUR

All but two of the interviewees were strong in metacognitive skills: they had thought about their learning approaches and had a reasonable congruence of motive and strategy. Overall 60.102 students levels of metacognitive behaviour compares favourably with studies involving tertiary students (Marland, 1990; Svenson, 1983, Watkins, 1986) in which students demonstrated minimal use of planning and checking strategies in their work.

S07's summary of his learning approach is characteristic of the generally high level of metacognitive awareness and control exhibited by the interviewees.

"Learning is unique to the individual - they should examine their motive and choose a learning style appropriate to their own situation."

It is possible that students who are highly metacognitive and thus aware and in control of their learning process are more likely to be attracted to the Campus Course. Thus one must be careful not to be over optimistic as to the overall level of metacognitive behaviour of 60.102 students.

Is the high level of metacognitive behaviour related to the context of distance education? Students, when considering the advantages and disadvantage of learning in an extramural environment offered the opinion that one must be more aware of one's motive for taking the course and know what are appropriate learning strategies and be able to control these effectively.

They appear to be very aware of constraints and advantages of working in a distance education environment and try to minimize constraints. Some constraints may challenge students into a Deep Approach but more frequently extrinsic constraints, such as a heavy workload and little time encourage a Surface approach.

S38 *"By not having contact I have to think through a lot more. I can't take things for granted. I'm responsible for my own learning. It's an advantage in the long run as you have to go out and do it; even if you want help you have to go and ask. There is no one asking the questions for you - you have to think about it for yourself."*

S35 *"Extramural students need a lot of patience and time to sit and think about problems. Sometimes its like being stranded on an island: you have all the things to get off but they are not quite in your reach; you have to be patient and put ideas together slowly."*

5.8 SUMMARY

To learn you must be able to monitor your understanding and apply corrective procedures when you have not understood. Students inability to monitor their understanding and engage in self-explanations appears to be a significant contributing factor to poor performance. Students must be encouraged to attempt to identify the reason for their difficulty to understand. This presents real difficulties for the extramural student who is isolated from "feedback" and results in those "hours of work" going in the wrong direction. Students reported that the use of solution booklets were invaluable for helping when "stuck".

In view of the examples of metacognitive behaviour reported by the respondents it is apparent that the learning Approaches of Deep and Achieving are likely to be significantly more effective when students are consciously aware of their own learning processes and try and deliberatly to control them.

Given that there are limits to the approach of improving learning by assigning more explanatory instructional material (as discussed in student use of worked examples) an alternative approach is to focus on the learner, and teach better learning strategies.

6 CONCLUSIONS

6.1 APPROACHES TO LEARNING

The evidence from this study is quite strong that distance education students exhibit learning approaches that can be classified according to Biggs' model learning into Surface, Deep and Achieving approaches.

Deep Approaches exemplify the type of learning that a tertiary institution expects students to demonstrate. In contrast to findings of Marland (1990) this research found that the majority of respondents reported high use of Deep Approach in their learning. This concurred with the Study Process Questionnaire results which resulted in a significantly higher Deep Approach Mean Score than that found in Biggs' study (1987b).

The intention of the Deep Approach learner is to understand and gain mastery of the concepts and a gain a firm hold on detailed factual knowledge. Students using a deep Approach generally felt that some specific learning tasks required rote, particularly in the initial stages, with understanding developing gradually. Although students endeavoured to gain an overview of the course content it proved an elusive task for many. Pressure of work and assignment routines meant for most students understanding the section at hand became the immediate priority, with links between topics developing later if at all. The on campus course provided the first opportunity for many students to take "time out" and reflect on the course as a unified whole.

Characteristically Deep Approach students' motivation was mainly intrinsic in nature. Those students wishing to continue their studies in mathematics were more likely to employ a Deep or Deep Achieving Approach.

In contrast the Surface Approach learner focused intention on task completion resulting in low quality learning, geared to short-term requirements. Surface learners' approach to learning mathematics was reliant on memorization of procedures; they were concerned with "getting the answer right/assignment done" to the exclusion of knowing

how to get it and what it means when it has been obtained. Their learning was characterised by limited understanding and connections between the topics.

It was significant that many of these learners were well aware of the limitations, in terms of understanding, of this approach. Their motives were mainly extrinsic in nature, such as gaining qualifications or completing a compulsory prerequisite, thus surface strategies could be justified in terms of their short term goals. Awareness of their Surface Approach strategies may explain why Low performers had similar (in fact slightly higher) motive/strategy congruence correlations scores (SPQ Scores). This contrasts Biggs (1987b) who argued that high performance is due partly to the expected higher motive/strategy congruence, which increases the effectiveness of any particular learning approach.

An Achieving Approach is based on achievement motivation and deals with the context, making the best use of time and working space. The achieving approach can be linked to either surface or deep: one can rote-learn systematically or in a disorganised way, or seek meaning in an organised or disorganised way.

Those students wishing to continue their studies in mathematics were more likely to employ a Deep or Deep Achieving Approach whereas those students completing the paper for a qualification only were more likely to use Surface and Achieving Approaches. In terms of relationship between examination performance and approach, high performers consistently reported medium/high combinations of both Deep and Achieving approaches.

Presage factors have an immediate effect on performance, but also each is likely to affect in various ways the students' motives for undertaking learning, and the strategies adopted in the learning process. Time was the most significant presage factor for the extramural students in this study. In view of the fact that pressure of time for study was the most likely factor likely to encourage Surface strategies, where possible course controllers should allow flexibility in the study program to accommodate individual time scheduling.

6.2 METACOGNITIVE BEHAVIOUR

This research was not designed specifically to address the area of metacognitive skills in mathematics but clearly it is a mediating factor in learning approaches and outcome. Learning was not solely a function of what content knowledge students brought to the task, but also of what they did with that knowledge. Students who failed to analyze the task adequately or to plan or monitor their performance inevitably achieved low grades.

To learn one must be able to monitor ones understanding and apply corrective procedures when one has not understood. The ability to monitor ones understanding was seen to be a key factor in the effective use of worked examples.

Unlike other studies of tertiary students (Borasi & Rose, 1989; Marland, 1990) it was found that distance education students exhibit strong metacognitive skills. The majority of students demonstrated evidence of planning, monitoring their strategies and checking their understanding.

It is not conclusive from this research as to why this should be so, but increased metacognitive ability is expected for older students who are intrinsically motivated and have a wide learning experience and are strongly oriented towards self-direction in their learning. (Biggs & Telfer, 1987)

Teaching material and course organization, should where possible aim to improve students metacognitive skills and deepen their approach to learning, which would in turn increase the structural complexity of their learning, and the amount of satisfaction derived from it. In particular there is a need to provide some encouragement and guidance in the area of checking. There were examples of students using checking skills as a procedure but failing to use them metacognitively as a monitoring strategy.

Although it is clear that knowing about ones learning process is necessary in self-directed learning, the research evidence on possible ways to teach or develop metacognitive awareness and skills in students is indecisive. Biggs and Telfer (1987) found that study skills may be taught blindly as tactics or metacognitively as strategies. If a student is not metacognitive about how to use a skill appropriately, but simply learns it as primary content, then the skill displaces the content the student should be learning.

Ramsden (1988) concluded that we should teach specific knowledge domains in such a way that a student's general capability is developed at the same time; we should not teach "metacognitive skills" as such, but should encourage students to reflect on learning in a specific content domain.

Rowe (1989) suggests the following activities to promote metalearning:

1. Learning Diary - shifting the focus of learning from the products of cognitive activity (the answers) to the process taking place during learning can help students to become more active monitors of their own learning.

   An extensive discussion of the value of keeping a journal is provided by Borasi and Rose (1989).

2. Demonstrate and discuss appropriate learning strategies,

3. Encourage self reports

4. Provide opportunities for feedback

5. Promote opportunities for self questioning and rating comprehension. Particularly students must be encouraged to attempt to identify the reason for their difficulty to understand.

To encourage more metacognitive awareness we need to discourage students concentrating all their learning on "Getting the assignment done". The nature of the assignment questions should encourage Deep Approaches, possibly they could include written response questions re process, checking and alternative procedures.

The aims, expectations and types of learning activities need to be made explicit in Study Guides. Students need to be aware of levels of mastery and understanding required and possible strategies available to monitor this understanding if they are to be active in constructing their knowledge.

In order to encourage students to reflect on the mathematical processes of mathematical thinking such as specialising, generalising, conjecturing, course material is to include problems specifically designed to draw attention to these processes and to provide practice in using them.

6.3 PRIOR KNOWLEDGE

Study Guides of first year papers must acknowledge students prior knowledge, especially in light of the fact that a large number of students are returning to mathematics after a considerable break in studies.

> *"Teaching is the process of organizing and relating new information to the learners previous experience, stimulating him to construct his own representation for what he is encountering." (Wittrock, 1977, cited Biggs & Telfer, 1987)*

Learners try to link new information to what they already know in order to interpret the new material in terms of established schemata, thus if a section of material relies on a knowledge of trigonometry, implicit differentiation etc, the background material should be readily accessible to the student.

Failure to do this for some sections in the 60.102 Study Guide resulted in many students resorting to Surface techniques or spending excessive amounts of time finding information and subsequent student frustration.

6.4 STUDENT USE OF TEXTUAL MATERIAL

In using textual material students reported a strong reliance on worked examples, especially surface learners who preferred to rely on worked examples rather than the textual material. For Surface learners, example solutions provide an algorithmic procedure to use and follow with similar problems in the assignment: little deep understanding is acquired from the example. Surface learners, using the worked example for these ends, failed to generate statements of self explanations linking the principles in the text to the example content. They avoided where possible examples that proved difficult and often failed to monitor their misunderstandings, glossing over difficult steps.

However for the majority of the extramural students, learning mathematics was viewed as a constructivist process. In learning to solve problems students need to construct new information in terms of concepts, build problem schemata and attach procedures to the problem schema. Worked examples were seen as a vital link between the principles introduced in the text and the formulation of this new information. These schema were then tested and extended by the problem solving activities offered by the exercises and assignments.

The construction process was facilitated by the self explanations offered by the individual student, each tailored to fit his or her existing schema. These self-explanations induced greater understanding of the principles introduced in the text. The production of these self explanations seemed to be guided by the accuracy with which the students monitored their understanding. The good students' self monitoring yielded specific questions through which they could search for an answer whereas poor students' self enquiries were rather more undirected.

Recent research into use of textual material has concerned the role of the worked example in the learning process. It is argued that when learning problems in a new area, the student tends to use means ends analysis: this facilitates a problem solution but interferes with schema acquisition and rule automation. Worked examples can focus attention on problem states and their associated moves, thus reducing cognitive load. This should facilitate learning and subsequent problem solving to a greater extent than actually engaging in the solution process.

Despite the evidence of the value of worked examples it is widely acknowledged that practice (exercises) is necessary for the development of automaticity. (Resnick & Ford, 1981) What is necessary is that students know how to process the worked examples effectively; that is they use the specializations of the principles in the text to reconstruct their own generalizations.

6.5 THE CONTEXT OF LEARNING

> *"The different approaches provide part of the solution to the enigma of how qualitative differences in understanding come about. An approach to learning, far from being an individual characteristic of a learner, is a response to the teaching environment in which the student learns. It is the student's subjective perception of the requirements of teachers - the context of learning - that is the driving force behind much of their learning." (Ramsden, 1988, p 21)*

Many researchers argue that the most significant single influence on students' learning is their perception of assessment (Biggs, 1989; Leder & Gunstone, 1990; Marland, 1990; Ramsden, 1988). Similarly this research found assignments to be very important to all students; the reason for this importance varies as does the individual students learning approaches.

Surface approach students use the assignment questions as a guide to "what is to be learnt". They are more likely to preview the questions at the beginning of each section and finish a section when the assignment is complete. The designing of assignment question in sequence with the text minimized the student's interaction with the exposition in the text. In light of their reliance on the assignment in determining the nature and extent of their learning it is extremely important that the assignment questions be designed to assess content which is central to the section.

Thus assessment activities should be designed to promote interaction with the text - not just tasks which require the student to search the text for clearly recognizable and ready made answers. Assignment questions should encourage a Deep Approach, not only providing data about students' abilities to reproduce information, but also about qualitative differences in their levels of understanding of key concepts.

In so far as assessment is in the teacher's control, he or she must endeavour to ensure the this most visible feature of the learning context provides a clear message about what changes in students conceptions are required. Perhaps an option is to include more questions relating to process such as written responses, alternative answers and checking procedures.

Eg. 1 Test the independence of these vectors using two different approaches and briefly discuss the merits of each approach.

Eg. 2 A student gave this answer as the solution to this problem. Rather than redoing the problem check the answer using an appropriate checking procedure and justify whether the student's answer is correct or not.

Or, Do you think your answer is correct? Justify your conclusion.

Eg. 3 When determining whether area is preserved in the given transformation we have used the Determinant of the matrix. Which theorem are we using and can you find another example of a transformation which preserves area?

Eg. 4 Can you draw a diagram representing the given vector problem?

Students using a Deep Approach to learning are less influenced by the assignment regarding it as an extension to their learning and using it as a test of understanding and mastery of concepts/procedure involved in each section.

Activities such as quiz questions and exercises which course designers feel are integral to their teaching may not be perceived as such by their students. Respondents rarely completed all the exercises with many doing only those exercises that time allowed. Students need to be aware of the value of their activity in the process of their learning if they are to become active constructors of their knowledge.

It is not only important that instructional and assessment procedures be structural enough to encourage Deep rather than Surface approaches, but course controllers must also be metacognitive enough to accept feedback on these procedures. It is not enough to assume that course materials or assessment methods will encourage students to think deeply about their subject matter: it is necessary to consider the students' perspective on what is required.

The implications for future research are that it is impossible for learning defined from a constructivist perspective to be content and context free learning. Techniques and instructional strategies are inextricably linked to the content and the students' perceptions.

7 RECOMMENDATIONS FOR FURTHER RESEARCH

This research has highlighted three major areas for future research involving mathematics distance education students:

1. the design of course material, in particular the use of worked examples,

2. metacognitive behaviour and

3. student perceptions of course organization and assessment.

The Design of Course Instruction

It is quite clear that differing approaches to learning used by groups of students lead to different outcomes thus it is important the material be designed so as to encourage Deep learning and minimize Surface approaches. Research must examine the students' use of the material in the context of their learning.

There are many distance education variables which can be further investigated which may have an influence on students' approach to study. Research into variables such as instructional design, provision of campus courses and quality of assignment feedback may reveal more ways in which students' approaches to studying can be modified.

The recent research concluding that a heavier than normal emphasis on worked examples can have a beneficial effect on schema acquisition, compared with a similar emphasis on problems suggests further research on use of worked examples under actual learning conditions. Specifically the evidence that by eliminating the need for a means-ends strategy, attention is appropriately directed resulting in reduced cognitive load and more effective schema acquisition, suggests research into the design of mathematics examples is needed.

There are many questions to be answered as to what makes a "good" worked example format, how many examples should text contain and what part do they play in the learning process.

Metacognitive Behaviour

Metacognitive behaviour is seen to have a mediating role in the effectiveness of an approach to learning. An important element of metacognitive behaviour is monitoring of comprehension. An awareness of misunderstandings potentially leads to further processing that may result in understanding. In light of research which shows that only good students monitor their state of comprehension accurately there is a need to research ways in which all students can be taught to monitor their comprehension more sensitively and accurately. Such questions as "Can course material be designed to induce student awareness of their learning process?, and Do distance education students, who are necessarily independent learners exhibit a greater degree of metalearning skills than their internal student counterparts?" need also to be answered.

In order to describe what causes good students to know that they understand and poor students not to know, we need to have a better account of the mechanisms underlying understanding, and the way that understanding relates to the use of worked examples and exercises.

Students' Perceptions

Because students react to the requirements they perceive, not always the ones the teacher defines it is necessary that research explores students' perceptions of the educational setting in which learning is taking place.

> *"It is the student's subjective perception of the requirements of teachers - the context of learning - that is the driving force behind much of their learning...unfortunately, what students perceive teachers will reward may lead these students to adopt the opposite approaches to those that will enable qualitative changes in understanding to occur." (Ramsden, 1988. P 21)*

Of particular relevance to distance education is the students' perception of learning mathematics and assessment and how it affects the quality of what they learn.

A constructivist position of learning implies that future research must involve exploring students' conceptions of mathematics and how these can be changed. A conception has two parts to it: the idea being conceptualized and the person doing the conceptualizing. Thus research should focus on the relation between a student and what the student learns.

Research must provide opportunities for teachers to study their students' learning, what misconceptions they hold, what specific activities of processes are involved in carrying out key tasks in mathematics and what constitutes deep and surface approaches in handling these task. The results of research using this perspective are about the material that teachers work with - the ideas of their students.

BIBLIOGRAPHY

Alexander, P & Judy, J. (1988)
The Interaction of Domain - Specific and Strategic Knowledge in Academic Performance. Review of Educational Research, Vol 58, No 4, Pp.375-404

Ausubel, D.P. (1963)
The Psychology of Meaningful Learning. New York, Grune & Stratton.

Baath, J.A. (1986)
Learning by written material. Epistola, 2.

Baird and White (1982)
Promoting Self-Control of Learning. Instructional Science II, Pp. 227 - 247.

Biggs, J,B. (1978)
Individual and group differences in study processes. British Journal of Educational Psychology, 48, 266-279.

Biggs, J.B. (1985)
The role of meta-learning in study processes. British Journal of Educational Psychology, 55, pp. 185-212.

Biggs, J.B. (1987)
Reflective Thinking and School Learning. Set, No 2, Item 10.

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

Biggs, J.B. (1987b)
Student Approaches to Learning and Studying. Australian Council for Educational Research, Melbourne.

Biggs, J.B. (1989)
Approaches to the enhancement of tertiary Teaching. Higher Education Research and Development, Vol 8, No 1, Pp.7-25.

Biggs, J.B. and Telfer, R. (1987)
The Process of Learning, Sydney: Prentice-Hall of Australia.

Blais, D. M. (1988)
Constructivism- a theoretical revolution for algebra. Mathematics Teacher, Nov, Pp. 624-631.

Borasi, R. & Rose, B. (1989)
Journal Writing and Mathematics Instruction. Educational Studies in Mathematics, 20, Pp 347 - 356.

Candy, P.C. (1989)
Constructivism and the study of self-direction in adult learning. Studies in the Education of Adults. Oct,89. Pp.95-116.

Chi, M.T and Bassok, M. (1990)
Learning from examples via self-explanations. Pp.251-282. In Knowing, Learning and Instruction. Edited by Resnick, L.B.

Cohen, L. and Manion. (1989)
Research Methods in Education. 3rd Edition. Routledge: London.

Cooper, G.A. and Sweller, J. (1987)
The effect of schema aquisiton and rule automation on mathematical problem solving transfer. Journal of Educational Psychology, 79, Pp. 347 - 362.

Denzin, N. K. (1988)
Triangulation. Educational Research. Methodology and Measurement. An International Handbook. Edited by Keeves, J. Pergamon Press.

Entwistle, N. and Ramsden, P. (1983)
Understanding Student Learning. London: Croom Helm.

Flavell, J. H. (1976)
Metacognitive Aspects of Problem-solving. In L. B. Resnick (Ed). The Nature of Intelligence. Hillsdale: Lawrence Erlbaum.

Ford, N. (1981)
Recent approaches to the study and teaching of "effective learning" in higher education. Review of Educational Research, Vol 51, No 3, Pp. 345-377.

Harper G. and Kember D. (1986)
Approaches to study of distance education students. British Journal of Educational Technology, 3, 17, Pp. 212 - 222.

Hunt, L. (1991)
Thesis, PHD (Massey University), In publication.

Kember, D. and Gow. (1989)
A Model of student approaches to learning encompassing ways to influence and change approaches. Instructional Science, 18, 263-268.

Kember D. and Harper G. (1987)
Approaches to studying research and its implication for the quality of learning from distance education. Journal of Distance Education, Vol 2, No 2, Pp. 15-30.

Kember, D and Harper, G. (1987a)
Implications for instruction arising from the relationship between approaches to studying and academic outcomes. Instructional Science, Vol 16, No 1, Pp. 35-46.

Knight, G. (1987)
Distance education in mathematics. Studies in Mathematics Education, Vol 16. Edited by Morris, R. Paris, UNESCO.

Knight, G., Alder, J., Davies, J. and Harrison, K. (1990)
Adult Distance Education.

Lather P. (1986)
Research as praxis. Harvard Educational Review, Vol 56. 3, Pp. 257-277.

Leder, G. C. and Gunstone, R. F. (1990)
Perspectives on mathematics learning. International Journal of Education Research, Vol 14, No 2, Pp.105-120.

Marland P., Patching W., Putt I. and Putt R. (1990)
Distance learners' interactions with text while studying. Distance Education, Vol 2, No 1. Pp. 71 - 91.

Marton, F. (1981)
Phenomenography - Describing conceptions of the world around us. Instructional Science, 10, Pp 177-200.

Marton, F.; Hounsell, D. & Entwistle, N. (1984)
The Experience of Learning. Edinburgh: Scottish Academic Press.

Marton, F. and Saljo, R. (1976)
On qualitative differences in learning, outcome and process II. British Journal of Educational Psychology, 46, 115 -127.

Mathison S. (1988)
Why triangulate? Educational Researcher, March.

Minnis, J. R. (1985)
Ethnography, case study, grounded theory, and distance education research. Distance Education, Vol 6, No 2.

Owen, E. and Sweller, J. (1989)
Should Problem Solving Be Used as a Learning Device in Mathematics? Journal for Research in Mathematics Education, Vol 20, No 3, 322-328.

Ramsden, P. (1988)
Studying Learning: Improving Teaching. Improving Learning, Edited by Ramsden, P. Kogan Page, New York.

Resnick L. (Editor),(1990)
Knowing, Learning and Instruction. Hillsdale, N. J: Lawrence Erlbaum Ass; New York.

Resnick, L. & Ford, W. W. (1981)
The Psychology of Mathematics for instruction, Hillsdale. New Jersey: Lawrence Erlbaum Association.

Roberts D. (1986)
Student study patterns. Open Learning, Nov.

Rowe H. (1989)
Teaching Learning Strategies. Set Research, No 1,Item 4

Shipman, M. (1981)
The Limitations of Social Research, 2nd edition. New York: Longman.

Shuell, T. J. (1986)
Cognitive conceptions of learning. Review of Educational Research, 56, 411 - 436.

Skemp, R.R. (1979)
Intelligence, Learning and Action. Chistester/New York, Wiley.

Small, M.W. (1986)
Learning Strategies. Australian Advanced Adult Education, Vol 26. No 1.

Svenson, L.; Lawrence, J. and Willis, S. (1983)
Distance University Students' Processing of Mathematics Exercises, Educational Studies in Mathematics. 14, Pp.73-85.

Svensson, L. (1977)
On Qualitative differences in learning, III- Study skills and learning. British Journal of Educational Psychology, 47,233-243.

Sweller, J. (1988)
Cognitive lead during problem solving: Effects on learning, Cognitive Science, 12, 257-285.

Sweller, J. and Cooper, G.A. (1985)
The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction, 2, 59-89.

Tarmizi and Sweller, J. (1988)
Guidance during mathematical problem solving. Journal of Educational Psychology, 80, 424-436.

Thornley, G. and Hendy, M. (1986)
Geometry and Linear Algebra. Dunmore Press Ltd, Palm Nth, New Zealand.

Thorpe, M. (1987)
Student Activities. Epistola. Vol 2, Pp. 11 - 30.

Van Rossum E.J. & Schenk S.M. (1984)
The relationship between learning conception, study strategy and learning outcome. British Journal of Educational Psychology, 54, 73-83.

Ward, M. and Sweller, J. (1990)
Structuring effective worked examples. Cognition and Instruction, 7(1), 1-39.

Watkins, D. (1982)
Identifying the study process dimensions of Australian university students. The Australian Journal of Education, 26 (1), Pp 71 - 85.

Watkins, D. (1983)
Depth of Processing and the quality of learning outcomes. Instructional Science, 12, Pp 49 - 58.

Watkins, D. (1986)
Improving Tertiary Learning. Set Research, No. 2.

West, L. (1988)
Implications of Recent Research for Improving Secondary School Science Learning, in Improving Learning. Editor, Ramsden, P. Kogan Page, New York.

Wittrock, M. C. (1974)
A generative model of mathematics learning. Journal for Research in Mathematics Education, 5, 181-196.

Zhu, X. and Simon, H.A. (1987)
Learning Mathematics from examples and by doing. Cognition and Instruction, 4, 137-166.

APPENDIX 1 60:102 EXTRAMURAL STUDENT STUDY PATTERNS DIARY

Please record every half-hour (or smaller interval) of study you complete on the study of material contained in STUDY GUIDE SECTION FOUR, including the completion of the assignment.

Please enter the category of the predominant activity involved: a list of suggested categorizations is provided below. If you spent approximately equal time on two activities enter them both, see 26/2/90 entry. At the conclusion of each study session make a brief comment on the study session: this may include reports as to the value of the activity, difficulties experienced, sucesses achieved etc.

Example Format of Diary

TIME	ACTIVITY	COMMENTS on STUDY SESSION/DATE
8·00 – 8·30	2a 1a	Finding this section difficult 13/5
8·30 – 9·00	2a	Although I don't really understand
9·30 – 10·00	2a	the theory, I can do the examples
8·30 –	2	Need to take care with 14/5
	2a	all these little figures
10·00	3, 3a	Better progress now.

LEARNING ACTIVITIES - CATEGORIES

0. Reviewing marked assignment.

1. Reading your text or study guide
1a. Reading your text or study guide and making notes/underlines
1b. Reading assignment questions.

2. Working through examples in text (using pen and paper as opposed to reading)
2a. Working through recommended exercises.
2b. Working through extension exercises.

3. Working on assignment questions.
3a. Writing out final draft of assignment.

4. Referring back to text examples, notes or previous worked exercises.

5. Referring to written sources outside the course material.

6. Consulting with another person, discussion of problems etc.

7. Any other "study" activity not mentioned above. Please specify what kind of activity below.

APPENDIX 2

LEARNING MATHEMATICS QUESTIONNAIRE

NAME_____

Please write your answers in the spaces provided; if you wish to write fuller answers feel free to use the other side to continue. Where possible please justify your answers rather than just giving a Yes/No.

Why are you taking this course?

Have you understood the material in this Section.?

What aspect of your study process was the most effective in learning the material?

Is the assignment an appropriate form of assessment for the Study Guide material?

What influence did the assignment questions have on your method of study?

Have you done sufficient work on this Section?

Was the workload for this Section about right?

APPENDIX 3 STUDY PROCESS QUESTIONNAIRE INSTRUCTIONS

Each item is a self-report statement on the learning process. You are to read the statement carefully and rate, as best as you can, using a 5-point scale.

```
5       4       3       2       1
1_______1_______1_______1_______1
```

5 -- corresponds to "This item is always or almost always true of me."

1 -- corresponds to "This item is never or only rarely true of me."

STUDY PROCESS QUESTIONNAIRE **NAME**_____

SCALE		STATEMENT
____	1.	I chose my present course largely with a view of improving my job prospects rather than out of its 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 my course 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 like to be told precisely what to study in the study guide.
____	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 read all notes and examples from the text and answer the quiz sections.

____ 7. I am discouraged by poor results on an assignment and worry about how I will do on the next one.

____ 8. My main reason for doing this course is so that I can learn more about that which really interests me.

_____ 9. I have a strong desire to excel in my study of this course.

____ 10. I learn some mathematics by rote, copying methods with no understanding.

____ 11. In learning 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 to a regular study program.

_____ 13. Whether I like it or not, I can see that further education is for me a good way for career advancement.

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

____ 15. I 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 have some understanding before I am satisfied.

_____18. I try to do my assignments as soon as possible after I receive them.

____ 19. Even when I have put a lot of work into an assignment I worry that I have not done it well enough.

____ 20. I find that studying mathematics can at times be as exciting as a good novel or film.

____ 21. If necessary I am prepared to sacrifice a leisure activity to spend time on my study program.

____ 22. I generally restrict my study to the compulsory exercises as I think it is unnecessary to do anything extra.

____ 23. I fine it helpful to "map out" a new topic for myself seeing how the ideas fit together.

____ 24. After I have completed my assignment problems I check all answers.

____ 25. One shouldn't be expected to spend significant amounts of time on material/ exercises that are not going to be examined.

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

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

____ 28. I prefer courses to be clearly structured and highly organized.

____ 29. I find most new topics interesting and often spend time completing quiz and extra exercises or further reading from another source.

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

____ 31. I almost resent having to spend the time studying but feel the end results will make it 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 competitive game, and I play to win.

____ 34. I find the best way for me to understand what technical terms mean is to remember the text-book definitions.

____ 35. I often find myself questioning things that I read in the text or study guide.

____ 36. I make a point of completing most of the compulsory and optional exercises from the study guide.

____ 37. I am doing extramural study mainly because I feel that I will be able to obtain a better job if I improve my qualifications.

____ 38. I find studying mathematics so interesting I should like to continue with further study after I finish this course.

____ 39. I believe that society is based on competition 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 the topic.

____ 42. I keep well organized notes for the course.

ADDITIONAL INFORMATION

Please select the most appropriate responses.

1. AGE

18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	57+

2. FURTHER STUDY

___ I intend to study this course to a higher level.

___ I intend to study further mathematics papers.

___ I plan to continue tertiary study but not include mathematics papers.

___ I am undecided on future study plans.

___ I have no plans for any further study at tertiary level.

APPENDIX 4 INTERVIEW OF 60.102 STUDENTS

Q.1: Why are you doing 60.102?

Q.2: Are you enjoying studying?

Q.3: What effect does studying mathematics extramurally have on your study methods?

Q.4: When starting a new section of work can you describe your overall approach?

Q.5: When reading/studying text what do you do?

Q.6: Specifically, when studying text examples, what do you do?

Q.7: How important are worked examples to your learning?

Q.8: Work through this Example form the text: Example 9/3.

Q.9: How do you study the Exercises in the text, how important are they?

Q.10: When do you tackle assignment questions?

Q.11: How do you know when you have learnt a topic?

Q.12: What advice would you give to another student on how to learn mathematics extramurally?

APPENDIX 5 STUDY PROCESS QUESTIONNAIRE RAW SCORES

	MOTIVES AND STRATEGIES						APPROACHES			
	SM	SS	DM	DS	AM	AS	SA	DA	AA	DAA
CODE										
S01	26	24	25	21	26	28	50	46	54	100
S02	22	20	31	15	21	18	42	46	39	85
S03	25	27	25	28	27	25	52	53	52	105
S04	17	20	28	20	22	26	37	48	48	96
S05	18	19	31	28	24	31	37	59	55	114
S06	21	20	23	23	18	28	41	46	46	92
S07	18	25	25	19	25	13	43	44	38	82
S08	26	23	24	23	25	17	49	47	42	89
S09	18	14	25	29	17	26	32	54	43	97
S10	13	15	32	26	15	24	28	58	39	97
S11	27	22	18	23	21	28	49	41	49	90
S12	14	13	31	26	20	26	27	57	46	103
S13	24	21	15	17	15	18	45	32	33	65
S14	13	22	24	21	20	18	35	45	38	83
S15	20	22	28	26	23	24	42	54	37	101
S16	13	20	21	19	14	30	33	40	44	84
S17	14	14	29	25	17	23	28	54	40	94
S18	18	24	20	19	16	22	42	39	38	77
S19	19	18	28	25	27	29	37	53	56	109
S20	20	26	22	20	21	25	46	42	46	88
S21	22	23	29	22	27	17	45	51	44	95
S22	7	11	34	27	20	32	18	61	52	113
S23	23	22	30	30	24	24	45	60	48	108
S24	19	22	23	20	21	33	41	43	54	97
S25	21	21	16	21	14	20	42	37	34	71
S26	19	27	31	24	21	12	46	55	33	88
S27	29	19	15	17	16	18	48	32	34	66
S28	23	21	27	33	22	14	44	60	36	96
S29	23	28	22	26	27	29	51	48	56	104
S30	24	21	27	27	25	32	45	54	57	111
S31	23	20	30	22	18	26	43	52	44	96
S32	16	21	24	22	22	26	37	46	48	94
S33	17	10	33	31	15	29	27	64	44	108
S34	26	18	22	26	16	15	44	48	31	79
S35	14	16	28	24	17	22	30	52	39	91
S36	20	21	20	17	17	18	41	37	35	72
S37	27	22	27	24	19	30	49	51	49	100
S38	16	16	32	32	19	26	32	64	45	109
S39	25	25	24	19	28	22	50	43	50	93
S40	18	17	21	29	16	33	35	50	49	99

APPENDIX 6 DECILE SCALE SPQ SCORES AND CATEGORIES

CODE	SURFACE		DEEP		ACHIEVING		DEEP-ACHIEVE		MARK
S01	9	H	7	M	10	H	9	H	30
S02	4	M	7	M	4	M	8	H	64
S03	9	H	9	H	9	H	10	H	59
S04	3	L	7	M	8	H	8	H	87
S05	3	L	10	H	10	H	10	H	63
S06	4	M	7	M	7	M	7	M	66
S07	5	M	6	M	4	M	5	M	86
S08	8	H	7	M	6	M	6	M	29
S09	1	L	9	H	6	M	8	H	68
S10	1	L	10	H	4	M	8	H	87
S11	8	H	4	M	8	H	6	M	82
S12	1	L	10	H	7	M	9	H	50
S13	6	M	1	L	2	L	2	L	40
S14	2	L	6	M	4	M	5	M	64
S15	4	M	9	H	8	H	9	H	61
S16	2	L	4	M	7	M	5	M	53
S17	1	L	10	H	4	M	7	M	52
S18	4	M	3	L	4	M	3	L	54
S19	2	L	10	H	10	H	10	H	92
S20	6	M	5	M	7	M	6	M	64
S21	6	M	9	H	7	M	8	H	23
S22	1	L	10	H	9	H	10	H	67
S23	6	M	10	H	8	H	10	H	50
S24	4	M	5	M	10	H	8	H	61
S25	4	M	3	L	3	L	2	L	27
S26	6	M	10	H	2	L	6	M	47
S27	7	M	1	L	3	L	2	L	61
S28	5	M	10	H	3	L	8	H	61
S29	9	H	8	H	10	H	10	H	79
S30	6	M	10	H	10	H	10	H	52
S31	5	M	9	H	6	M	8	H	53
S32	2	L	7	M	8	H	7	M	50
S33	1	L	10	H	7	M	10	H	-
S34	5	M	7	M	2	L	4	M	69
S35	1	L	9	H	4	L	7	M	85
S36	4	M	3	L	3	L	2	L	63
S37	8	H	9	H	8	H	9	H	67
S38	1	L	10	H	6	M	10	H	66
S39	8	H	5	M	9	H	8	H	54
S40	1	L	9	H	8	H	9	H	59

A Chi Square analysis showing significantly different distributions for Deep Approach Scores of respondents to that of Biggs (1987b)

Categories	**Observed**	**Expected**
LOW	5	12
MEDIUM	14	16
HIGH	21	12
	n = 40	

Observed : respondents' scores
Expected: Biggs' standardized distributed

TEST STATISTIC

$$\chi^2 = \frac{\Sigma(O - E)^2}{E}$$

$$= 11.08$$

which is $> \chi^2_{0.01,2}$ so distribution is significantly different from Biggs' standardized distribution.

Comparing mean Approach scores of Science students (Biggs, 1987b) with mathematics respondents' mean Approach scores shows a significant difference (at the 0.01% level) for Surface and Deep Mean Scores.

1. SURFACE MEAN SCORES

$H_0 : \mu_{maths} = \mu_{sc}$
$H_1 : \mu_{maths} < \mu_{sc}$

Statistics: $\bar{x}_{maths} = 40.20$ $\bar{x}_{sc} = 43.61$
$s_{maths} = 7.98$ $s_{sc} = 7.57$

$$\text{Test Statistic } Z = \frac{(40.20 - 43.61) - 0}{\sqrt{\frac{(7.98)^2}{40} + \frac{(7.57)^2}{248}}}$$

$$= -2.53$$

Conclusion: Accept H_1 (at 0.01% level)

2. MEAN DEEP SCORES

$H_0 : \mu_{maths} = \mu_{sc}$
$H_1 : \mu_{maths} > \mu_{sc}$

Statistics: $\bar{x}_{maths} = 49.15$ $\bar{x}_{sc} = 43.71$
$s_{maths} = 8.15$ $s_{sc} = 7.87$

$$\text{Test Statistic } Z = \frac{(49.15 - 43.71) - 0}{\sqrt{\frac{(8.15)^2}{40} + \frac{(7.87)^2}{248}}}$$

$$= 3.94$$

Conclusion: Accept H_1(at 0.01% level)

APPENDIX 9

Pearson Product-Moment Correlation of STRATEGY/MOTIVE

	SS	SM	DS	DM	AS
S strategy					
S motive	**0.542****				
D strategy	-0.348**	-0.165			
D motive	-0.400**	-0.445**	**0.507****		
A strategy	-0.293*	-0.215	0.294*	0.159	
A motive	0.531**	0.300*	0.085	0.244	**0.027**

* significant at the 10% level
** significant at the 5% level.

FIG 15

Correlation between Motive/Strategy
for High (>60) and Low (<60) Performers.

	High Performers	Low Performers
SURFACE	0.492**	0.624**
DEEP	O.344**	0.528**
ACHIEVING	0.223	-0.093

* significant at the 10% level
** significant at the 5% level.

FIG 16