CHAPTER ONE

INTRODUCTION TO PROJECT

1.1 PROJECT OVERVIEW

"All you can do, if you really want to be truthful" advises Feyerabend (1991, p. 141) "is to tell a story." This is my story about university students' learning of statistics. These students were not studying statistics out of choice, but as a service course to second year Psychology at The University of Sydney. I shall use Statistics, with a capital "S", throughout this thesis, to refer to the compulsory component of Psychology II being studied by the participants in this investigation. This delineates the context of my investigation. Since the majority of the participants in my investigation are female, I shall use "she" as the generic term. My research aims to understand students' learning of Statistics through their orientations to it within the learning context. I explore students' conceptions of Statistics, their approaches to learning it, their evaluations of learning it, outcomes such as performances on tests and examinations and how these relate to the learning environment.

The position of the narrator is important in any story. My interest in these students arises from my work at the Mathematics Learning Centre. The Centre is a small department in the College of Sciences and Technology at The University of Sydney. I am one of three mathematics educators who make up the academic staff. The Mathematics Learning Centre was established in 1984 with the aims of increasing access to mathematics, as well as improving the completion rates for students studying mathematics and statistics at university. The staff of the Centre are involved in bridging courses and preparatory courses and provide ongoing support for students of The University of Sydney who are having difficulty with basic level mathematics and statistics courses. Students in a wide range of courses are assisted by means of individual tuition and weekly small group workshops which supplement their mainstream tutorials. Typically, we offer help in mathematics and statistics to over 450 university students annually. Students attend the Centre voluntarily.

I take personal responsibility for teaching the Psychology students at the Centre who are studying Statistics. One of my major concerns is to develop teaching methods (see Gordon, 1997a) which are innovative and appropriate for these students — arguably among the most anxious and unappreciative of university students concerning the study of a mathematical subject. One such student, who attended the Centre regularly, wrote this summary of her feelings about learning Statistics:

> I don’t feel confident with statistics.
>
> I don’t plan a career that would involve statistics.
>
> I don’t enjoy statistics.

The Psychology students I teach at the Centre seem to me like travellers who have been diverted from their route to this strange “Land of Statistics”. Some of them do not know what they are doing there. They do not speak the language and they follow desperately and blindly any sign which may get them out. (“Do you ALWAYS do t-tests in statistics problems?” asked one student.) My job as a teacher is to provide a map which enables students to choose the ways to their destinations — and to enjoy the journey. Research helps me draw this map.

My research about students learning Statistics is informed by activity theory. This theory was developed by a Russian psychologist, Leont’ev, and owes much to the far reaching and insightful ideas of Vygotsky, whose brief life and career took place in the former Soviet Union (Leont’ev, 1969, 1978, 1981; Vygotsky 1962, 1978). Activity theory posits a systemic view of human behaviour in which an individual’s goals and subjective perceptions are interwoven with socio-historical factors. Developed from Marx’ social economic theories, activity theory views human learning as active behaviour mediated by interactions with the social world. We learn by our engagements with other people and our cultural and historical environments.

This perspective has important analytic and practical implications. From an analytic point of view this theoretical perspective orients the researcher to an awareness of what Hutchins (1993, p. 62) calls “a serious overattribution of knowledge to individual actors”.

This means that if the individual mind is the focus of interpreting thought and learning, the contribution of the setting, cultural artefacts and social interactions may be hidden from analytic understanding. My perspective highlights the mutuality of the organising of individual knowledge by context and, in turn, the ongoing shaping of the learning arena by those acting within it. From a pragmatic point of view this research raises questions as to what statistics should be taught in the information era and how it is experienced by the students learning it. How are the messages sent by educators understood by the students receiving them? Are the actions of students congruent with the goal of university education in statistics, that is, high quality learning leading to enhanced perspectives of the world in which we live?

My assertion, based on the perspective of activity theory, is that students' views of statistical knowledge relate to their experiences of learning it as a whole. This view emphasises the need to shift attention away from considering learning statistics as an individual enterprise, independent of the context, to a more holistic view of the student, her actions and the learning environment surrounding her. Leont'ev's framework suggests, too, that in order to teach statistics effectively, we must first understand the learners — their goals, perceptions and evaluations of the statistics they are studying. The relevance of a learning task to the student provides the framework within which that student acts. This way of looking at thinking and learning suggests that, while teachers may try to emphasise the usefulness of statistics, no one can persuade a student of the power of a tool. This discovery depends on the student's experience of its functionality. In particular, the way a student monitors and controls her ongoing cognitive activity depends on how she reflects on her efforts and evaluates success. In Semenov's words:

> Thought must be seen as a cognitive activity that involves the whole person (Semenov 1978, p. 5).

Two studies were carried out to investigate the principal research question:

> **What are students' orientations to learning Statistics?**

This question will be clarified in Chapter Two (section 2.6). It is delineated into separate principal questions in each of the two studies which are further broken down into secondary questions. These will be elaborated in Chapter Four (sections 4.1.2.1 and 4.1.2.2). Study One explores the perceptions and actions of five older students who attended the Mathematics Learning Centre. I shall refer to these students as mature students to distinguish them from the younger adults who make up the bulk of university students. Study One consists of case studies of these five students with whom I worked intensively. I then widened the context of my inquiry to include the mainstream cohort of Psychology II students. A survey on learning Statistics was the basis of Study Two. It was completed by 279 Psychology II students. The students were surveyed during the Statistics lecture, with the cooperation of the lecturer concerned. The survey consisted of questions relating to demographic variables, such as age, gender and prior level of mathematics studied, three open-ended questions, and a Likert type questionnaire — the Approaches to Learning Statistics Questionnaire. (See Appendix F for survey.) Interviews with selected students were subsequently carried out in order to flesh out and clarify aspects of the survey responses.

Throughout this thesis I have consciously written in the first person as recognition of the inseparability of myself as a researcher and the research setting. I also use the word "participants", rather than "sample", to emphasise that the students who took part in each of the studies cooperated in my research.

In Study One I explore the following conjectures.

- The students identified two different sorts of statistics or mathematics — school mathematics and "life" statistics or mathematics.
- Actions were goal directed.
- The students' approaches to learning Statistics were related to how they positioned themselves with respect to the learning task.
- The students' metacognitive processes of monitoring and evaluation were paramount in defining their activities.

The findings from Study One informed the design of Study Two. In Study Two I examine a number of variables. These describe the participants and aspects of their experiences in learning Statistics. Most of the students surveyed were female, had previously studied mathematics at a level which included Calculus and were 18 or 19 years old. Different assessment tasks were given to the students. Achievements on these were, on the whole, consistent, and also agreed well with students' self ratings of their likely grades in Statistics. Students' marks in Statistics correlated strongly with their academic attainments on the non-mathematical components of Psychology II. Most of the students were averse to studying Statistics, because they found it boring or difficult. However, the subject was acknowledged as being necessary for Psychology. An analysis based on phenomenographic methods (Marton, 1986) revealed that a range of conceptions of Statistics was held by the students. Most of these conceptions, though (65%) fell into one of two categories: PROCESSES (algorithms or mechanical techniques) or MASTERY (over the material presented). The findings indicate that many of the students thought of the subject as being about understanding the prescribed content and solving the problems presented in class — unrelated to the practice of psychology and isolated from the wider world. Consistent with their view of the subject matter and their attitudes to studying it, students showed an overwhelming preference for surface approaches to learning Statistics, as indicated by their scores on the scales of the Approaches to Learning Statistics Questionnaire. This is strong evidence for students' approaches to learning Statistics as constituted in, and inseparable from, the context of their learning. Norman (in Study One) maintained that

> ... if I could guarantee enough knowledge to get full marks in the tutorial test and the stats exam and know that I forgot it all completely afterwards, I'd almost go for that course, because that's what they want.

If students believe that "that's what they want", then surface and expedient ways of learning Statistics are to be expected. Further, interviews with teaching staff (described in Chapter Eight) suggest that such beliefs are not without foundation.

Strong relationships were found among the variables measured in Study Two. In particular, the findings suggest relationships among facets of students' orientations to learning Statistics — their appraisals of learning Statistics, their conceptions of it and their approaches to learning it. Study Two also shows that students in the same class have strikingly different orientations to and outcomes of learning Statistics.

Unfortunately, the majority of the students were unwilling to learn Statistics, had perceptions of the subject mainly in terms of accumulating knowledge for assessment purposes and, on average, adopted surface approaches to learning it. While some of these students did well in tests and examinations, it is unlikely that many of them will transfer their knowledge to other environments. For a small group of able students, however, the picture is far more satisfactory. In addition to achieving high marks, on average, most of these students were motivated to learn Statistics, showed an awareness of the applications of the subject beyond the classroom walls and, on average, adopted deep approaches to learning it. An interesting and little acknowledged profile, described in Chapter Seven, relates to a group of students who, on average, did not perform well in assessments, despite adopting relatively deep approaches to learning Statistics. These students evidently had different goals and interpretations of the learning context to the conventional ones, perhaps putting their own interests ahead of assessment demands. Such students present a particular challenge to university educators.

The findings of this investigation suggest that we need to take a systemic view of the learning environment. That is, we should consider not only the content and the presentation of statistics, but also how the students perceive it and the context in which it is taught. This is best summed up by Leont'ev (1981, p. 126) as:

> Meaning mediates man's reflection of the world.

That is, individuals filter their experiences through their awareness of purpose or significance and it is this awareness that we need to understand in order to educate students of statistics. The importance of learning statistics at university should not be underestimated. For some students, their study of statistics is their first (and last) contact with learning a mathematical topic at university. Apart from the instrumental reasons for teaching statistics, this is the opportunity for educators to enhance the mathematical perspectives of these students — and so their insights into their worlds. Further, an ability to interpret the information with which we are bombarded is a minimal safeguard against disempowerment. Sandra (in Study One) summed up most poignantly her feelings about conquering mathematics for the first time in her life. She said:

> It felt very good, it felt a lot like growing up. All my life it felt like I had this dark secret:— that I felt really stupid about this area. I'd cover it up so no-one would know. It really felt like growing up.

1.2 CHAPTER PREVIEW

Chapter One briefly summarises the position of the participants in this investigation, including my own aims and approach. Chapter Two defines the framework for my investigation. I introduce the theoretical model based on activity theory and review the literature on statistics education at university. I outline my research design and approach and introduce some of the methods I used in the two studies, including the phenomenographic method (Marton, 1986) which I found a useful analytic tool, and one compatible with the relational view of activity theory. In Chapter Three I develop the theoretical framework on which my interpretation rests. I explain Vygotsky's ideas as the forerunners of activity theory and the re-interpretations, extensions and new directions pursued by Leont'ev. I elaborate on the tenets of activity theory and apply them to my own setting. I explore issues relating to current interpretations of the theory. In Chapter Four I describe my methodology — research questions, design, approach, assumptions and strategies. I specify my procedures and research tools, as these apply to each of my two studies.

Chapters Five, Six and Seven concern the investigations undertaken to answer the research question. My findings in Study One are explained in Chapter Five. As suggested by Leont'ev's theoretical framework (Leont'ev, 1981) the research question is investigated at different levels in this study. The levels are treated as layers. The outer layers are factors pertinent to the context, both personal history (experience, prior knowledge) and institutional factors. The inner layers reveal students' goals, actions and operations: how and why they act — their approaches to learning Statistics — and their perceptions of the conditions surrounding their learning. The heart of the study concerns these students' self regulation and evaluation as mediators of their actions. The results of Study Two are presented in Chapter Six and Chapter Seven. In this study I investigate students' reports of their actions, their conceptions of the subject matter and their feelings about their learning Statistics as revealed by a survey. I explore the dynamics of the students' activities by looking at relationships between the different aspects of their learning and the outcomes. These links and outcomes are described qualitatively and, in some cases, quantified. I firstly describe and explain the variables in Chapter Six and then explore the relationships among them in Chapter Seven.

Teachers are an important part of the organisational network surrounding learning. Their activities contribute to the shaping of the learner and the setting and, in turn, reflect this "arena" of action (Lave, 1988). Hence part of my understanding of students' learning of Statistics relates to interpreting the perceptions and actions of their teachers. Interviews with two academics involved with teaching Statistics are described in Chapter Eight. Chapter Nine is concerned with synthesising Study One and Study Two. Important and converging aspects of these studies are highlighted and anomalies identified. I interpret the ways that students' orientations to learning Statistics relate to and are organised within an institutional and cultural framework. Finally, in Chapter Ten, I analyse key issues that arise from the research. I explore perspectives provided by my research strategies and suggest directions for future research. I review my findings in terms of my dual aims. One is to illuminate theoretical constructs from activity theory. The other, as will be explained in section 2.3.3, is to apply and extend this theory in an investigation of individuals engaged in a "socially significant" practice (Chaiklin, 1993). In this way I try to contribute to an understanding of the relations between theory and practice in education.

CHAPTER TWO

INTRODUCTION TO RESEARCH FRAMEWORK AND THEORETICAL MODEL

Mathematics is what you make of it: It can be artistic, practical, creative or routine.

Quote from student survey on learning Statistics

2.1 INTRODUCTION

In this chapter I introduce the construct of activity (Leont'ev, 1981) and relate it to the particular forms of engagement with learning Statistics explored in this thesis. I review the current literature on research in statistics education and introduce some aspects of my methodology.

2.1.1 Chapter Preview

Currently, there is considerable research into the teaching and learning of statistics at all levels of education. In higher education, statistics education is a fast growing and important area. In the next section (2.1.2) I introduce my perspective on activity theory pertaining to statistics education. In section 2.2 I summarise some of the literature on statistics education relevant to my investigation and outline some issues arising from the research. Following that, in section 2.3, I introduce some aspects of my research design and approach. While full details of my methodology and procedures are provided in Chapter Four, I give some background to the two studies making up the project in this section — who the participants were and the setting for each of the studies. I explain the fundamentals of the Gothenburg phenomenographic method (Marton, 1986) and my adaptation of it for Study Two. I outline the ideas underlying my development of the Approaches to Learning Statistics Questionnaire. I also explain how my study fits into an emerging form of research (Chaiklin, 1993) concerned with investigating individuals engaged in socially meaningful practices. In section 2.4, I introduce my theoretical model, drawing on Leont'ev's framework. This is a precursor to Chapter Three. I firstly look at other important theories informing mathematics education and how activity theory fits with them. I describe some key elements of activity theory and include some major influences on its development in the former Soviet Union. I explain the structure of activity and its analysis. In sections 2.5 and 2.6 of this chapter, I frame my project, including the principal research question, in terms of an activity theory approach. Finally (in section 2.7) I summarise the key ideas of this approach.

2.1.2 Introduction To My Perspective On Activity Theory

The theory of activity, based on the work of Vygotsky (1962, 1978, 1981a, 1981b) was expounded mainly by A. N. Leont'ev (1969, 1978, 1981). It was an extremely influential theory in the former Soviet Union, and was developed and extended by important psychologists there, including Luria, Gal'perin, P. Ia. Zinchenko, and, after them, Davydov, V. P. Zinchenko, as well as many others (see, for example, Davydov, 1990, 1993; Gal'perin, 1969; Luria, 1976; P. Ia. Zinchenko, 1981; V. P. Zinchenko, 1995). It emphasises the role of external, practical activity in cognition (Davydov, 1990; Wertsch, 1981, 1985). According to Leont'ev (1978, p. 59) it is an important proposition that:

> internal psychological activities originate from practical activity, historically accumulated as the result of the education of man based on work in society, and that in separate individuals of every new generation they are formed in the course of ontogenetic development.

That is, higher mental abilities develop in the individual from activities that are rooted in the ongoing practical and communal life by which societies organise and reorganise themselves.

The philosophical foundations for this approach are the theories of Marx, Engels and Lenin. Their concern was with the economic foundations from which development arises, both individual development and societal progress. Following their theories, Leont'ev explained that people actively develop knowledge on the basis of life experiences, which have an economic, social and political context, and are mediated by cultural tools. The idea of mediation arises from Engel's proposition that the work done by humans is mediated by the tools they develop. Vygotsky extended the idea of physical tools as mediators to include mediation of cognitive processes by psychological tools — speech and semiotic systems. An eminent Western analyst of Leont'ev's activity theory, Wertsch, describes the activity framework as being concerned with how abilities are developed:

> to carry out socially formulated, goal-directed actions with the help of mediating devices (Wertsch, 1981, p. 32).

While the Russian word *deyatel'nost'* (Leont'ev, 1981, p. 37) is commonly translated into English as "activity", the ideas incorporated in the construct are, to me, better embodied in the word "engagement". This word conveys notions of purpose and affect and includes intellectual, as well as physical, processes. All of these are bound up with the social world surrounding the individual. Activity, in ordinary English usage, usually refers to physical activity — behaviour. Indeed, in early Russian publications, activity referred to physical labour, which was mediated by tools. Later, the notion of activity was developed to include mental actions, such as remembering and reflection, and included Vygotsky's idea of mental tools as mediators, rather than only material tools of work. I will elaborate on these developments of activity theory in Chapter Three. Activity, in the sense of engagement, both produces thought and is a product of the individual's awareness — her reflection on her environment.

According to Leont'ev (1981) activity, with its corresponding goals, means and conditions, dialectically forms and reforms individuals and their social worlds. That is, activity both orients individuals in the world in which they live and changes that world in cycles of mutual transformations. Activity is described by Leont'ev (1981, p. 46) as a functional unit of life:

> a system with its own structure, its own internal transformations, and its own development.

In section 2.4.4 below, and throughout this thesis, I will try to explicate Leont'ev's ideas about the configuration of an activity system as a functional and dynamic unit. In this way I try to shed light on how students' learning activities develop and how they both shape and are organised by the setting surrounding them.

The activity of learning is a process in which people grapple with new information — to make it meaningful, to solve problems and to adapt to new conditions. Rather than stressing the nature of the information received by the learner, the emphasis of my investigation is on the individual acting in her social and cultural world — what the learner does, why she takes those actions and how her actions relate to the learning arena. Varela, Thompson and Rosch (1991, p. 205) describe cognitive capacities as:

> paths that exist only as they are laid down in walking.

Their metaphor beautifully illustrates the inseparability of personal meaning and setting; the co-emergence of thought and action. These notions are fundamental to my interpretation, application and extension of activity theory. Activity theory emerged from a culture and era very different to my own. The insights offered by this theory, in part due to these very differences, highlight the problematic nature and complexity of human learning.

2.2 STATISTICS EDUCATION AT UNIVERSITY

"Statistics" said Jane, a mathematics student:

> really fits my logic and it feels right. Maybe the men have finally invented a good mathematical study for a change.

The above comment highlights the tension between knowledge as culturally endorsed and the individual's personal appraisal of it, a tension not always as agreeably resolved as in Jane's case. Statistical literacy and appreciation, particularly an understanding of data gathering, presentation and interpretation, are important components of undergraduate and graduate education in many fields. They are also essential for modern living in technologically developed countries. Statistics is often a compulsory unit of university courses, such as Psychology, Economics, Business or a Health Science, because it is an important tool for analysing the "uncertainties and complexities of life and society" (Mosteller, 1989 p. ix). Despite this importance, many students in statistics courses are reluctant to study it. Indeed, Cotts (1994, p. 479) maintains that it is:

> almost unarguable that the introductory statistics course is the most widely feared course on most university campuses.

This conviction is echoed in several studies (reviewed in Gal & Ginsburg, 1994).

2.2.1 Research In Statistics Education

There has been considerable research into statistics education in the last thirty years. This interest in the teaching and learning of statistics is not only a part of the general growth spurt in mathematics education (Schoenfeld, 1994) but is also a field of research in its own right. Four international conferences, the International Conferences on the Teaching of Statistics (ICOTS), have been devoted to grappling with issues relating to statistics education. Much topical literature concerns the teaching and learning of statistics at all levels of education. For example, in a special edition on teaching statistics of the *Journal of Educational and Behavioural Statistics,* Becker (1996) reviews 530 articles and dissertations which are documented on electronic databases such as the Educational Resources Information Centre (ERIC). Almost all these articles (97%) were published after 1970 and about one third have appeared since 1990. A bibliography on the available literature published between 1987 and 1994, concerning the teaching of probability and statistics, is provided by Sahai, Khurshid & Misra (1996). This shows that the body of work being done in this area is extensive and growing. Truran & Truran (1996) review Australasian research into the learning and teaching of stochastics, for the period 1992-1995, which reflects the current importance of probability, statistics and combinatorics to education in my region of the world. Electronically based journals such as the *Journal of Statistics Education* (Dietz, 1997) and Web discussion groups (for example, *Teaching-statistics@mailbase.ac.uk*) facilitate the extensive exchange of ideas and the development and distribution of research among participants in statistics education.

The quantity and scope of the published literature, as well as the ongoing discussion and research, is a strong indication of current interest in statistics education. The literature and discourse concerns many topics. One important topic concerns teaching strategies. For example, Lan (1993) writes about self monitoring and Smith (1992) discusses the use of writing assignments in teaching statistics. The role of computers, multimedia materials and other technological aids in teaching statistics is an area of increasing prominence (Lipson & Jones, 1997; Marcoulides, 1990; Moore, 1993; Velleman & Moore, 1996). Individual differences, such as gender differences in learning statistics, have also been investigated. For instance, Clark (1993) proposes that female students prefer statistical questions which have a people-orientation. Preliminary results by Forbes (1997) however, suggest that, in statistical examinations in New Zealand, the form and type of examination questions, for example, whether questions involve essay writing or require using Calculus, are at least as important as their contextual embedding in determining gender preferences and performance. As with any other field in education, what constitutes statistical knowledge and how to enhance the quality of students' learning of it, are key problems in statistics education (Huberty, Dresden & Bak, 1993).

A major theme that recurs in the literature on higher education in statistics pertains to teaching and assessing statistics. There is general consensus in the community of statistics educators that reforms are urgently needed in the teaching of introductory statistics courses at university (Cobb, 1993; Hogg, 1991; Mosteller, 1988; Snee, 1993; Williams 1993). Some university educators describe teaching activities and/or methods of assessment intended to address the problems — to make statistical concepts meaningful and useful — to relate statistics to the real world. For example, Anderson & Loynes (1987) and Pfannkuch (1997) discuss what abilities and skills are needed by practising statisticians and how to teach these. Garfield (1993) Giraud (1997) and Keeler & Steinhorst (1995) describe new ways of teaching statistics using co-operative learning activities. Garfield (1994) and Hubbard (1997) present frameworks for developing assessment instruments and procedures which are appropriate for measuring students' understanding and applications of concepts in probability and statistics.

Many university educators report on the success of their statistics courses by describing enhanced performance and/or increased student satisfaction. However, as some researchers point out, little is known about how such courses would transfer to other settings (Romero, Ferrer, Capilla, Zunica, Balasch, Serra & Alcover, 1995). Becker (1996) concurs with this view. In her review of the literature and other resources on teaching statistics, she focuses mainly on statistics education at the university level. She reports that this literature is largely anecdotal, with less than 30% of the reviewed articles describing the results of empirical studies. Hence, extensive information on instructional strategies and resources are available to tertiary educators in statistics, either in print or through electronic media. However, research empirically evaluating the teaching and learning of statistics is less copious. Further, and in stark contrast to the literature on mathematics education, there is a dearth of studies on the teaching and learning of statistics which are framed in terms of theories of education. The literature on teaching and learning statistics at the tertiary level tends to concentrate on the "knowledge craft" (Becker, 1996, p. 72) of the teachers.

A further and major area of research in statistics education concerns students' understanding of particular concepts in statistics and probability theory. This research shows that many students have difficulties with and misconceptions about statistical ideas (see Garfield & Ahlgren, 1988). Konold (1995) reviewed research showing that the intuitions of adults are at odds with accepted probability and statistical theory. Fischbein and Schnarch (1997) investigated the stability of students' misconceptions in probability across different age levels from grade 5 to college students. Surprisingly, they found three different outcomes: some misconceptions grew stronger with age, some grew weaker and one remained stable. Vallecillos & Batanero (1996) presented a study on the persistence of conceptual errors in university students' understanding of levels of significance in tests of hypotheses. There are also sections on students' understanding and misunderstanding of concepts relating to probability and statistics in books on the teaching of statistics such as Green (1994); Holmes (1986); Hawkins, Jolliffe & Glickman (1992). These attest to the importance of conceptual understanding as a goal of statistics instruction.

In summary, research on student learning in statistics shows that students have difficulties with statistical concepts and that they are often anxious about and have poor attitudes to learning statistics. The body of research on teaching and learning statistics is large, vibrant and growing. However, much of it still lacks the systematic methodology and theoretical foundations that are often of the most lasting value in any field of education. Further, a concern with describing teaching strategies or students' attitudes or their misconceptions, while indicating an awareness of the problems facing statistics education, does not offer a model for understanding the impasse — a first step towards alleviating it. My approach is to explore the issues underlying this impasse within a theoretical framework which relates students, their actions and the context (see also, Gordon, 1995c).

2.2.2 Issues For Exploration In My Research

The acknowledgment, in the education literature, of the prevalence of students' misinterpretations of key statistical concepts leads me to question how statistical thinking is embedded in academic settings. That is, how do students experience statistical reasoning in the academic setting and how does this reasoning relate to that of working statisticians in practical situations? According to one statistician (in Pfannkuch, 1997) the components of statistical thinking are: understanding the dynamics of the real world problem, moving towards a statistical model and using statistical tools. If students in a university statistics course are not provided with experiences enabling them to understand the relationship between the statistical model and the “real life” situation, they may not be adequately equipped to use the statistical tools with which they are presented and so may be unable to appreciate the statistical reasoning process. For example a lack of understanding about variation could lead students either to trust implicitly their own intuition about data, without attempting to use statistical reasoning to evaluate the findings more critically, or to distrust universally any statistical statement — without the means to assess its reliability. It is important for me in this investigation to understand how students’ concepts of statistical knowledge relate to the contexts in which they apply this knowledge.

The ways that students experience learning statistics are also likely to contribute to the difficulties that many students have with the subject and to their objections to studying it. How students understand statistics is related to how they interpret it in the context in which it is presented. This is an aspect of students’ learning of statistics which has received scant attention in the research literature and, in my experience, is rarely accorded importance in the teaching of statistics courses in higher education. Skills and facts are easily identified in the design and assessment of statistics courses at university. However, students’ conceptions of the subject matter as a whole, approaches to learning it and their perceptions and beliefs are rarely evaluated in any formal sense. These aspects of students’ learning of Statistics are major topics for exploration in my project as it is a prime postulate of my research that these are critical dimensions of students’ emerging statistical knowledge.

In learning Statistics, a student’s thinking and problem solving is accompanied by affective elements: feelings, beliefs, desires and attitudes which will affect how long she will persist with a task or a problem, how easily distracted she is likely to be, how long she will remember facts and skills and other important factors which can facilitate or hinder her cognition. Affect is therefore of importance and interest in my investigation which seeks to understand learning Statistics from the activity theory (Leont’ev, 1981) perspective. In this framework, affective elements are not extraneous or secondary to intellectual processes but indivisible from them. Vygotsky (1962, p. 150) describes this inseparability of intellectual processes and affective elements as follows:

> Thought itself is engendered by motivation, i.e. by our desires and needs, our interests and emotions. Behind every thought there is an affective-volitional tendency, which holds the answer to the last 'why' in the analysis of thinking. A true and full understanding of another's thought is possible only when we understand its affective-volitional basis.

Hence, the affective components of students' cognitive processes give those processes their "attitudinal colour" (Varela et al, 1991, p. 43).

Statistics is included in the curricula of many disciplines at university in order that students may use it and appreciate its relevance to their chosen fields. In Western countries, statistical thinking is bound up with technology, commercial concerns and other matters of cultural importance. The social interests and preoccupations of a culture are not, however, automatically assimilated by individuals, but are monitored. Students regulate their thinking and actions according to their evaluations of a learning task. What is culturally accepted may be personally abhorrent. There may even be a conflict between studying statistics and a student's perception of her own self realisation or values. For example, in the following survey response (in my pilot study: Gordon, 1995b) one student expressed the idea that real psychologists don't do mathematics. She wrote:

> I don't even see the point. In psych why must maths infiltrate itself??? Studies have shown that those who have high maths abilities have low or poor communication & perception skills — shouldn't psychologists be exceptionally perceptive & able to communicate well? It seems that if there aren't silly numbers to justify things then they aren't plausible in our computer/maths/ science promotive society

Leont'ev (1978) makes an important distinction between meaning and personal sense, which relates to conflicts such as the one expressed by this student. To Leont'ev, meanings are connected with the reality of the outside objective world, the life of society. Leont'ev (1978, p. 169) calls them the "crystallization of social experience". Personal sense, on the other hand, is connected with the reality of the person's own life and motives. That is, personal sense involves the incorporation of socially constituted meanings into the psychology of the individual. Personal sense, according to Leont'ev (1978, p. 92) "does not have its own 'supraindividual', 'nonpsychological' existence". Sometimes, as for the student quoted above, there is a mismatch between societal and personal meaning. According to Leont'ev, it is affect that signals to the individual the fit (or misfit) between the two. I will discuss this further, with reference to my findings, in Chapter Nine (section 9.2.1.1)

Lerman (1996) argues that the valuing of decontextualised, intellectual processes, divorced from personal and social elements, is expressive of oppressive discourse. It is this privileging of abstract thought, such as academic mathematics, that is disempowering for some students. Sierpinska & Lerman (1996) refer to the vested interest mathematicians have in maintaining the status of mathematics in society. This idea was passionately expressed by a participant in my pilot study for Study Two (Gordon, 1995b). She wrote:

> Maths is an exercise in agony, because the people who teach it make one feel as though maths belongs in a higher plane of evolution. Even though the number system is for everyone, and the concepts are there for everyone, the feeling (especially if you are doing pass options) that you do not deserve to know anything runs rampant. Maths, in short, is a lofty pain and a real headache to study.

In summary, the issues that I am concerned with in this project relate to the ways that students orient themselves to and interpret the task of learning Statistics and to how personal dimensions and individual actions are linked to the wider social, institutional and cultural arenas surrounding them.

2.3 INTRODUCTION TO RESEARCH DESIGN AND APPROACH

The activity theory perspective suggests that a focus on teaching, unrelated to students' perceptions about their own learning and its context, is unlikely to be successful in changing outcomes. My approach focuses on the experience of learning Statistics at university from the point of view of the student. Consistent with my theoretical framework based on the ideas of Leont'ev and Vygotsky, I explore the network of relationships between learners, the subject matter and context.

My investigation took place at a large and traditional metropolitan university, the oldest in Sydney. The participants were second year Psychology students, all of whom were required to study Statistics. Statistics is introduced in first year Psychology at The University of Sydney, but it is as a compulsory component of the second year course that it plays a major role, contributing one quarter of the final assessment mark. The instruments I used included participant observation, interviews and surveys. My project consists of two investigations. Study One is entitled "Exploring Mature Students' Learning of Statistics". The context for this study was the Mathematics Learning Centre where I work. The participants in this study were of great interest to me as an educator concerned with ameliorating students' difficulties with Statistics. Study Two is called "Understanding University Students Learning Statistics as a Service Course to Psychology". In this study, I widened the context of my inquiry to include the general Statistics class. These studies will be introduced below in sections 2.3.1 and 2.3.2. For my investigations, I drew on a triad of research tools — naturalistic inquiry, procedures based on the phenomenographic method (Marton, 1986) and quantitative methods for describing data and exploring patterns and relationships. The procedures I followed will be explained in Chapter Four. Background to phenomenography as a research tool is provided below in 2.3.2.1. Among the instruments I developed was the Approaches to Learning Statistics Questionnaire. I outline the basis for this questionnaire in 2.3.2.2, below. Further details of its development are provided in Chapter Four (section 4.5.6).

2.3.1 Psychology Students At The Mathematics Learning Centre

In Study One I utilise a naturalistic perspective to draw on the rich accounts of five students who were studying Psychology after many years away from the educational setting. My aim is to tell the story of these students in a way that is generalisable to others — that is, I try to uncover recognisable insights. I was in no way involved with the formal assessment of these students and worked very intensively and closely with them. Hence I was able to develop a close relationship with the participants of Study One and had more access to their perceptions and feelings than is usually the case for university educators in statistics.

My analysis is based mainly on interview data, complemented by written expressions from various sources, as will be explained in Chapter Four (section 4.4). The five participants were selected “purposively” (Lincoln & Guba, 1985) for their range of experiences and attributes. As is often the case with qualitative research, the data for this study consisted of descriptions, direct quotations and excerpts, obtained by close psychological contact with those being studied. The study is an example of action research in that my actions as a researcher were inseparable from those designed to assist the students in their learning of Statistics. As I have outlined in Gordon (1995a) this means that the methodology for the study developed through the “action research spiral” (Carr & Kemmis, 1986, p. 165). They describe this spiral as recurring cycles of:

> planning, acting, observing and reflecting, with each of these activities being systematically and self-critically implemented and interrelated.

2.3.2 A Broader View Of Psychology Students Learning Statistics

Study Two was grounded in Study One and broadened the perspective on students learning Statistics. The participants of Study Two were Psychology II Students who took part in a survey during their Statistics lecture, near the end of the first semester. The survey was completed during 20 minutes of the lecture time and was the major source of data for this study. Other data for this study included assessment results and vignettes from interviews with students selected from those who agreed to contribute further to my research.

2.3.2.1 Background To My Application Of Phenomenography As A Research Tool

One major focus of Study Two was to elicit students’ conceptions of the subject matter, in the context in which they were studying it. To do this I adopted a phenomenographic approach. The term phenomenography was first used by Ference Marton (1981) to describe programs of research which had the common aim of describing peoples’ conceptions. The results of phenomenographic analysis are categories of description of the qualitatively different ways students conceive of the phenomenon being investigated (Marton, 1986). This focus on describing conceptions is not the sole aim of the investigations in which phenomenography is used as a research tool. Rather it is learning and teaching that are being investigated based on the focusing of conceptions (Svensson, 1994). Conceptions are the lens through which the phenomenographic researcher views learning.

Marton (1986, p. 31) describes phenomenography as a method:

> for investigating the qualitatively different ways in which people experience, conceptualise, perceive and understand various aspects of, and phenomena in, the world around them.

Phenomenography was developed within the framework of education research at the University of Gothenburg, Sweden. It is concerned with the relations between people and the objects of their perceptions or content of their thoughts. Marton (1986, p. 36) calls phenomenography a “research specialization”, that is, a combination of a research orientation and a research approach to describing and comparing conceptions and understandings. The research orientation emphasises the importance of description and the use of categories as forms of expressing the conceptions. The research approach is characterised by the open explorative form of data collection and the interpretative analysis of data.

Säljö, a forerunner in the development of the phenomenographic approach, comments that in more recent studies, the term “way of experiencing” is used in preference to the term “conception” (Säljö, 1997, p. 175). This emphasises that:

> the prime interest of phenomenographic research (in Marton’s interpretation) is in finding and delimiting the variation in ways of experiencing reality (Säljö, 1997, p. 175).

Hence, in deriving categories of description for students’ conceptions of Statistics, I am attempting to find relationships between the students and the subject matter which express their ways of experiencing the subject, Statistics, as they were learning it.

Svensson (1994, p. 12) argues that underpinning the phenomenographic specialisation is an assumption that knowledge is fundamentally a “question of meaning in a social and cultural context”. Such an approach views phenomena systemically and avoids separating person and context. As Säljö (1991, p. 184) in an editorial of *Learning and Instruction,* concludes:

> Human experiences are inescapably cultural in nature, and learning and growth take place within cultural boundaries.

This view of the intertwining of culture, mind and action is consistent with a Vygotskian assumption that there is no duality between self and context; between thinking and acting (Vygotsky, 1962, 1978). The phenomenographic view of knowledge is that it is relational, created through human thinking and activity which relates to the external world — a relation between thought and social and cultural life. Hence my choice of phenomenography as one of my research tools is consistent with the theoretical perspective with which I am framing this investigation.

The relational view of learning furnished by phenomenography has formed the basis of much of the research into student learning in higher education. Phenomenography has been fruitful in exploring students' conceptions and understanding in a number of topics, including physics (Prosser & Millar, 1989); literature interpretation (Marton, Asplund Carlsson & Halász, 1992); essay writing (Prosser & Webb, 1994) and computer programming (Booth, 1992, 1997). In summary, this research indicates that learners' experiences should be considered as involving the ways students relate to the learning environment, their goals and intentions, as well as their learning strategies.

My colleagues and I have found phenomenographic methods useful to explore the qualitatively different ways in which students experience learning mathematics. Two studies were conducted (Crawford, Gordon, Nicholas & Prosser, 1994a, 1994b). In the first study (Crawford et al, 1994a) we investigated the conceptions of mathematics and approaches to learning it of students entering university. In the second investigation (Crawford et al, 1994b) we explored these students' conceptions of a fundamental mathematical concept, namely that of a function. Traditionally, phenomenographic studies are built around interviews (Marton, 1986). However, in these investigations, my colleagues and I extended previous research by constructing categories from the written responses of a large number of students. This developed phenomenography as a research tool.

In Study Two, I built on our previous phenomenographic research by looking at the variation in the way second year Psychology students conceived of the nature of the subject matter, Statistics. The phenomenographic perspective provided my basis for identifying categories of description of students' conceptions. These revealed qualitatively different ways of experiencing Statistics. In much research, the categories of description or variables are imposed on the data by an expert researcher. In Study Two, in keeping with phenomenographic practice, the categories of description were constituted in relation to the data — from interpretations of the survey responses. This does not imply that I, as researcher, viewed the data free of ideas based on prior experience or theoretical orientation. Indeed:

> the act of categorisation is by its very nature subjective (Mousley, Sullivan & Waywood, 1993, p. 39).

Further, my research is deliberately set in the framework of activity theory. However, instead of characterising students' responses to the three open-ended questions in the survey (shown in Appendix F) by means of an established taxonomy, the categories emerged in the context of the study. By keeping the questions as general as possible, I tried not to shape students' responses. Rather I tried to explore the students' points of view. This enhances the ethnographic validity of this research, that is, the sense of the research in terms of the lives and awareness of the participants in it.

The phenomenographic method analyses meanings constituted within a particular context and content domain. My categories were derived in a particular setting. However, they and their structure as an organised set, may prove useful in contexts other than the one from which they emerged. In accord with the phenomenographic approach:

> the categories of description are supposed to be replicable, but the way in which they were found is not (Marton, Asplund Carlsson & Halász, 1992, p. 2).

Conceptions may be expressed in different forms of action but they are most accessible through language. Variation in conceptions, expressed by people, immediately brings in the cultural and social context in which these conceptions are reported. The students' reports on their ways of conceiving Statistics, although limited to the students' awareness and abilities in written verbal expression, provided me with a rich source of information for characterising these experiences. This experiential perspective is referred to as a "second order" perspective by Marton (1986, p. 33). He contrasts this with phenomenology, based on Husserl's imperative to return to the essence of a phenomenon, through immediate experience and free from conceptual thought — a first order enterprise. Phenomenography is a perspective on how things appear to people — how phenomena are experienced, rather than what they are "in reality" or whether or not such a reality can be described.

Phenomenography was derived from empirical and pragmatic research in education. Its commitment to philosophical foundations is therefore not always clear. The procedures defining its use are neither prescriptive nor indisputable. Indeed, Hasselgren & Beach (1997, p. 195) argue that "there is no genuine consensus method of phenomenography". To them:

> Phenomenography is research which is simply concerned with how things are understood, the experiences of the process of formation of understandings at individual levels, and their distributions in specific collectivities (Hasselgren & Beach, 1997, p. 195).

While my way of applying this research tool is individual, I have tried to maintain the essence of phenomenographic research as a way of understanding the multiple realities of students. That is, my appropriation of Marton's term signifies this approach. I view phenomenography as a research tool which bridges the gap between empirical, analytic methods, which are recognised by the research community, and students' subjective awareness of their own diverse conceptions and experiences.

2.3.2.2 Introduction To My Analysis Of Students' Approaches To Learning Statistics

I analysed students' approaches to learning Statistics by means of a questionnaire, the Approaches to Learning Statistics Questionnaire (ALSQ). My questionnaire was modified from the Approaches to learning Mathematics Questionnaire (Crawford, Gordon, Nicholas & Prosser, 1995; 1998) which, in turn, was derived by my colleagues and myself from the Study Process Questionnaire (Biggs, 1987).

Biggs (1987) refers to three approaches to learning: deep, surface and achieving. He differentiated each of these into two aspects — the motive, or intention, and the strategy. Hence, in the Study Process Questionnaire (Biggs, 1987) the items are divided into those referring to motive or intention and those referring to strategy. Each motive-strategy combination defines a distinct approach to learning — deep, surface or achieving. Early work by Biggs, on samples of students from universities and Colleges of Advanced Education, indicated that the achieving approach was equally related to the surface and deep approaches in tertiary students. The surface and deep approaches, however, are referred to by Biggs (1987, p. 15) as:

> independent ways in which students may become involved in learning.

In this project I was concerned with deep and surface approaches to learning. Achieving approaches were of less theoretical interest to me and were not investigated.

Considerable research has been done on the Study Process Questionnaire. For example, a literature review on approaches to studying (Richardson, 1994a) indicates that mature students seem more likely than younger students to adopt deep approaches to learning, while surface approaches decline with age. However, completion rates and possible bias in these studies, for example, in the postal returns of surveys in Biggs' (1987) investigations, renders this finding problematic. Richardson also reviewed the literature on cultural specificity of approaches to studying in higher education (Richardson, 1994b). Investigations using the Study Process Questionnaire in countries as diverse as Australia, Nepal, Britain and Nigeria yielded a similar two factor structure for this questionnaire — one indicating a deep approach and the other a surface approach (Richardson, 1994b). The research also suggests that orientations towards understanding the meaning of learning materials, that is, deep approaches to learning, reflect a consistent agreement across different cultures with regard to the goals of higher education (Richardson, 1994b). On the other hand, this research indicates that patterns of responses on the subscales measuring surface approaches to learning, are more distinctive to differing cultural contexts (ibid).

Concern has been expressed (Richardson, 1994a) about the factor structure underlying Biggs' differentiation of the Study Process Questionnaire into motive and strategy components. In my analysis of the Approaches to Learning Statistics Questionnaire (ALSQ) I did not find evidence for a breakdown into intention and strategy factors. I therefore analysed the items of the ALSQ in terms of two subscales: one measuring a general surface approach and the other a deep approach to learning Statistics.

Biggs (1987) characterises a surface approach and a deep approach to an academic task by the following.

A surface approach is distinguished by:

- a view of the task as imposed, a demand to be met;
- a fragmented view of the task — parts are unrelated to each other and the task is unrelated to other tasks;
- worries about the time taken by the task;
- a lack of recognition of any personal meaning in the task;
- reliance on memorisation and ways of reproducing the details.

A deep approach reflects:

- interest and enjoyment in the task;
- a search for underlying meaning;
- efforts to make the learning personally meaningful — relating task to personal experience or to the real world;
- holistic approach — relating parts of the task to each other and to other knowledge;
- theorising about the task.

The surface approach and the deep approach, as defined by Biggs, correspond closely with the surface and deep levels of processing distinguished by Marton and Säljö (1976a, 1976b). Later, Marton and Säljö (1984) referred to these as surface and deep approaches to learning. In contrast to Biggs, however, Marton and Säljö (1984) see surface and deep approaches as the opposite ends of a single continuum, rather than as independent ways of learning. Marton and Säljö (1976a, 1976b) showed that students would adopt one of two methods of processing information according to their intentions. If their aim was merely to memorise and reproduce material, or, as Biggs (1987, p. 11) puts it:

> to display the symptoms of having learned,

they would adopt a surface level of processing; if they wanted to maximise their understanding of the underlying meaning, they would adopt a deep strategy. Hence Marton and Säljö (1976a, 1976b) inferred a relationship between strategy and intention. What the student intends to gain from the learning determines the strategy used. In recent research, Marton, Watkins & Tang (1997) make the point that while a surface approach to learning is often associated with rote learning, this is not what characterises it.

> Rather, a surface approach is characterised by a focus on the learning material or task in itself and not, as would be the case for the deep approach, on the meaning or purpose underlying it (Marton, Watkins & Tang, 1997, p. 24).

Their ideas accord with Leont'ev's (1981) proposition that what distinguishes actions are the goals driving them.

2.3.3 Investigating Individuals In Socially Significant Practices

My project is an example of what Chaiklin (1993, p. 384) describes as "investigating individuals in socially significant practices". These are studies in a "yet-to -be-embodied" research tradition that:

> try and develop an account of the actions (or possibilities for actions) of individuals participating in a societally significant practice while it is occurring, by an analysis that locates the practice in a social, societal and/or historical perspective (Chaiklin, 1993, p. 386).

Chaiklin proposes that many different theoretical perspectives and methods could contribute to such research. He summarises such projects as having five common characteristics, which I assert are fulfilled by my project.

- Firstly, these studies take concrete, meaningful, societal practices as the direct object of study. That is, the setting for the study is an actual example of human practice and would be so whether or not it was the object of study. In my research I have tried to get as close as possible to the participants and interpret situations which were as typical as possible for students learning Statistics.
- Secondly, the practice takes place in a recognisable societal institution, in this case an institution of higher learning.
- Thirdly, such studies have a definite theoretical interest. Insights into the practice of learning Statistics are important elements of my research but so are insights into and extensions of the activity theory framework in which I have interpreted this practice.

- Fourthly, there is the idea that knowledge and actions are social as well as individual. I draw on Vygotsky's and Leont'ev's idea of "co-knowing" (Leont'ev, 1978, p. 60) to illustrate this notion — statistical knowledge is socially created and re-created through the consensus of practitioners. This collective development of knowledge is facilitated through tools, for example, by the easy and quick exchange of ideas through electronic media. In my university, Statistics is continually being transformed by each lecturer and committee involved in organising the curriculum and setting the examinations. Students come to know Statistics through interacting with peers and teachers, as well as through their own reflections and actions. Socially organised constraints and resources surround individual actions.
- Finally, the particular practice selected for such studies has:

> significant consequences for the people participating in these practices (Chaiklin, 1993, p. 385).

Learning Statistics can change the lives of those participating in this practice. In some cases, the outcomes could be instrumental in determining students' academic and career paths. For example, students' examination results in Statistics could determine whether they would attain a degree or be accepted into Psychology Honours. Learning Statistics can also powerfully affect students' personal development as was the case for some of the participants of Study One. This will be discussed in section 5.2.5.

In this project I have tried to piece together practical and theoretical perspectives to contribute to the building of a research framework— to an understanding of the relations between theory and practice in education.

2.4 THEORETICAL MODEL

2.4.1 Overview

In order to present a model of how learning Statistics is derived from statistical activity, it is important for me to explain both the context of the learning I am investigating and the theory by which I interpret the findings. Section 2.3, above, sets the scene for my two investigations. The research tools I use, such as naturalistic inquiry, phenomenography and statistical analyses, provide the means for investigating local occurrences. I use these tools to explore relationships and events as they occurred for particular individuals in a setting which was bounded spatially and in time. It is by means of the theoretical framework, that is, by my application of activity theory, that I try to provide insights that transcend the particular context. To start off, in section 2.4.2, I locate frameworks which draw on Vygotsky's theory in terms of some other major theories of education, particularly those which are currently important to research in mathematics education. An outline of activity theory, as expounded by Leont'ev, is given in sections 2.4.3 and 2.4.4. This will be expanded in Chapter Three. At the end of this chapter, I introduce my approach to understanding students learning Statistics from an activity theory perspective.

2.4.2 Comparison With Other Theoretical Approaches To Learning

Western researchers are increasingly finding that a Vygotskian perspective provides a helpful lens with which to view the complexities of mathematical learning (Kieran, 1994). This approach takes into account the fundamental role of social interactions and historical or cultural influences on learning. It aims to understand how language and symbols mediate meaning (Vygotsky, 1962, 1978). Vygotsky's work on cognitive development contributed to the evolution of cognitive psychology (West, Farmer & Wolff, 1991). In this framework, not only are the actions of learners important but also their goals and how the actions are situated in a sociohistorical context. For Vygotsky and the activity theorists who followed him, the context for all activity is important, and collective external activity precedes individual internal activity. The emphasis on the melding of the individual with society is particularly relevant to the analysis of adult learning, as adults are cognitively fully developed in the biological sense but generate new knowledge through participation in activities which are socially and culturally rooted. Hence, while Vygotsky's interest was mainly in the development of the child (Vygotsky, 1962) his explanation of learning through interpersonal interactions, and Leont'ev's interpretations and ideas, are useful for extending research on adult development (for example, Candy, Crebert & O'Leary, 1994; Knox, 1986; Merriam & Caffarella, 1991).

The Vygotskian framework provided a stimulus for theories of situated cognition (Lave, 1988; Lave & Wenger, 1991; Scribner, 1984) in which a setting is defined as the relationship between an actor and the arena in which she or he acts. Cognitive skills take shape in the course of individual participation in socially organised practices. Research into situated learning recognises the cultural dimensions of learning and practices, for example, the cultural aspects of literacy (Scribner & Cole, 1981); numeracy (Greeno, 1991; Saxe, 1991); apprenticeship (Rogoff, 1990) and interactive expertise or working intelligence (Engeström, 1992). Issues addressed by researchers working in this paradigm (for example, Crawford, 1994) often concern the effects of cultural artefacts — the devices and technologies, such as computers or internet systems, through which we "manipulate reality" (Säljö, 1991, p. 180). Varela et al (1991, p. 5) propose that knowledge is "amplified" by technology. To them, knowledge is seen as:

> tangibly and inextricably linked to a technology that transforms the social practices which make that very knowledge possible.

These issues are highly pertinent to a study of statistical learning, as statistics is an artefact of Western culture. It is linked to our technology and it both moulds our thinking — the way we understand our world — and is used to produce changes in our environment. Theories of situated cognition resonate with activity theory approaches in their recognition of cognition as constituted in the social, vocational and cultural life of people. Consonant with Leont'ev's theory (Leont'ev, 1981) research in this area acknowledges the role of tools in mediating cognition. However, in theories of situated learning, consideration is given to the importance of informal learning, an area little addressed by Vygotsky or Leont'ev.

One of the strengths of the conceptual frameworks provided by Vygotsky and Leont'ev is the integration of affective and motivational dimensions into explanations of cognition. There have been many researchers in diverse areas of education, who seek to show that motivational goals and intentions give meaning to learning — they are what drives the process. For example, Ausubel, Novak & Hanesian (1978) characterise all learning as meaningful learning. Ames & Ames (1989, p. 4) argue that goals:

> provide the mechanism for filtering perceptions and other cognitive processes.

Bandura (1977, p. 193) explains the link between intentions and behaviour by means of the construct of self efficacy:

the conviction that one can successfully execute (a given) behaviour.

Studies by Volet (1997); Volet & Chalmers (1992) and Volet & Lawrence (1989) show the importance of goals as mediators of university students' learning. Education research increasingly recognises that the attitudes, beliefs, motivation and intentions expressed by learners are important, not only for understanding the actions of those learners, but also for the insights provided into cognitive theory (Ames & Ames, 1989; Meece, 1996). However, much of the literature in the area of affect and motivation lacks a unifying theory (Carr, 1996). In Leont'ev's theory, the role of motivation and of goals in cognitive processes is systematised by means of his three levels of analysis of activity (Leont'ev, 1981). I will explain this in section 2.4.4.2.

In mathematics education, research into affect and related areas, such as beliefs and perceptions, is extensive. The breadth and depth of these studies reflect an awareness of the importance of charting the changing trends and many dimensions of affect in learning. For example, Mcleod (1994) reviewed the research since 1970 in the *Journal for Research in Mathematics Education* on affective issues in mathematics learning, showing that such studies are central to the goals of mathematics education. These studies explore many different aspects of the affective domain. One major area of interest to mathematics educators is that of students' attitudes to learning mathematics, particularly gender effects (for example, in Barnes & Horne, 1996). Fennema (1989) summarises work using attitude scales, such as the Fennema-Sherman Scale, for measuring gender effects in affective issues and achievement in mathematics. Her research showed major differences between males and females on a number of variables, such as confidence in learning mathematics, or perceived usefulness of mathematics. Recent work on the Fennema-Sherman Scale by Forgasz, Leder, and Gardner (1996) suggests that changes in response patterns challenge the reliance that has been placed on this important instrument. They recommend revising it, particularly the scale referring to mathematics as a male domain. This indicates that important transformations are taking place in students' attitudes to mathematics. An area of research related to attitude studies concerns students' perceptions and beliefs about mathematics. Schoenfeld (1989) pointed out that students' performances on mathematical problems were often undermined by their beliefs about mathematics, such as the belief that a mathematical problem should always yield a solution quickly. There have also been recent studies on factors affecting students' motivation to learn mathematics showing that classroom environment, goal setting and type of task are critical elements (for example, Grouws & Lembke, 1996). Research in statistics education, too, confirms the importance of students' attitudes, beliefs, interests, expectations and motivation to their learning (Gal & Ginsburg, 1994).

Affective issues are related to the ways in which students evaluate and regulate their learning — key elements in defining their activities. In this regard, a helpful distinction was made by Semenov, a Soviet psychologist, who applied activity theory to the study of thought processes. He distinguished the "intellectual plane of thought", which pertains to the development of the content of a problem, from the "personal plane of thought", which refers to the individual's evaluation of his or her efforts — reflections on the meaning and success of the ongoing mental activity (Semenov, 1978, p. 5). While Semenov was referring to problem solving, his distinction extends usefully to students' appraisals of studying a statistics course. In my project I will differentiate between students' so called "objective" or practical evaluations of Statistics — evaluations in terms of extrinsic and culturally framed factors such as jobs, or higher study, and their personal assessment of it in terms of their liking for or interest in it and feelings about learning it. (See, in particular, section 6.3.1.)

A framework for the role of values in learning mathematics was developed by Southwell (1995, 1997). This extends McLeod's (1992) research on the relationship between beliefs, attitudes and emotions in mathematics education. Southwell (1997, p. 459) sees values as closely related to beliefs but "more complicated and encompassing". She denotes values by a triangle consisting of the three elements of valuing: cognition, affect and volition. She does not distinguish between values and valuing, which renders her framework problematic to me. However, the three aspects of valuing she specifies, tie in with Semenov's (1978) notion, referred to above, that the plane of thought has intellectual and personal aspects. Southwell's (1997) notion that volition is an aspect of valuing also accords with Leont'ev's insistence that activity is purposeful. Leont'ev (1981) proposes that need always stands behind thought or action. However, unlike Southwell, Leont'ev (1969, 1978, 1981) explains how purpose, needs and goals are socioculturally framed. That is, he explicates these relations in terms of individual's activities, rather than simply stating that such relations exist. I will expand on these notions of Leont'ev in Chapter Three (section 3.3.2).

The focus on learning as "embedded in social situations, practices and cultures" (Engeström, 1992, p. 4) is one of the key elements differentiating activity theory from constructivism, a major theory in mathematics education. While activity theorists assert that all learning is socially constituted, constructivism emphasises that all learning is the construction of meaning by the individual. In both cases action is required on the part of the learner. Constructivist ideas are drawn initially from Piaget's work, but constructivism has developed in various forms, such as radical constructivism or social constructivism. Constructivist thinking has been instrumental in challenging the way educators regard learning — and therefore teaching. Piaget's work led to the idea that a mathematics classroom could be a place where children could direct their own learning, pose their own problems and discover their own mathematics. The impact of these ideas on research into mathematics education has been extensive, so much so that Ellerton (1997) asks whether we have become too comfortable with constructivism. What do we really mean by the constructivist teacher?

2.4.2.1 Relation Between Constructivism And Vygotskian Approaches

Vygotskian perspectives are often contrasted with theories of learning based on constructivism. A Piagetian approach considers learning as the result of individual constructions of the environment, namely assimilation and accommodation. Assimilation is the process whereby the individual integrates new perceptions or situations into her or his existing individual schemes, and accommodation is the individual's effort to adjust schemes to the environment (Piaget, 1954). The essence of this approach is the focus on the individual and on stages of maturation as prerequisites for the development of mental facilities.

Vygotsky recognised the genius of Piaget's work and was influenced by it, though disagreeing with Piaget's conception of:

> the role of egocentrism in the developmental relationship of language and thought (Vygotsky, 1962, p. 20).

According to Vygotsky (1962, p. 23):

> The developmental uniformities established by Piaget apply to the given milieu, under the conditions of Piaget's study. They are not laws of nature but are historically and socially determined.

Thus Vygotsky criticised Piaget for his failure:

> to take into account the importance of the social situation and milieu (Vygotsky, 1962, p. 23).

Piaget, in turn, was aware of Vygotsky's theories. Indeed, Piaget modified some of his theories in the light of Vygotsky's criticisms. However, Bodrova & Leong (1996) point out that this happened after Vygotsky's death. For this reason, the works of Vygotsky's students, more than of Vygotsky himself, have some common ground with Piaget's ideas. Bodrova & Leong (1996, p. 27) express the opinion that this:

> has caused many psychologists to erroneously consider the Vygotskian framework as part of Piaget's constructivist tradition.

Piaget, like Vygotsky, explained cognitive development, such as mathematical development, as a result of children interacting with their environments. However, while Piaget viewed learning as subordinate to development, Vygotsky (1962) insisted that learning, by which he meant formal or school learning, directly influences development. According to Vygotsky (1962, p. 85):

> Instruction is one of the principal sources of a schoolchild's concepts and is also a powerful force in directing their evolution; it determines the fate of his total mental development.

To Vygotsky, thinking itself, together with the cognitive structure required for thought and indivisible from the function of that thinking, is generated by internalisation of social relations. Meaning making takes on different forms in the interpretation by constructivists and Vygotskian theorists. In the former, it is a personal contribution of the learner who is involved in the education process. In a Vygotskian approach, meaning making is bound up with cultural values, such that:

> the qualities of thinking are actually generated by the organizational features of the social interaction (van Oers, 1992, p. 2).

Vygotsky (1978) explained that higher mental processes develop through interaction with others. He expressed this as follows (Vygotsky, 1978, p. 30):

> From the very first days of the child's development his activities acquire a meaning of their own in a system of social behaviour and, being directed toward a definite purpose, are refracted through the prism of the child's environment. The path from object to child and from child to object passes through another person. This complex human structure is the product of a developmental process deeply rooted in the links between individual and social history.

I will explain this further in Chapter Three (sections 3.2.2.2 and 3.2.2.3).

Knowledge to a constructivist is an individual construction; to the activity theorist it is a collective representation. This is not to intimate that constructivists deny the importance of the societal context, nor that there is no place for the individual in the Vygotskian viewpoint. Rather it is a shift in emphasis. Saxe (1991 p. 6) suggests of the Piagetian perspective:

> social life is related to cognitive development as an external process, and the way sociocultural life may be deeply interwoven with the character of intellectual functioning is unanalyzed.

In contrast, Bauersfeld (1994) calls activity theory a prototype of collectivist perspectives. A simplified overview of this perspective, provided by Bauersfeld (1994) is that learning is enculturation into pre-existing societal structures. This suggests a ready made world and knowledge, a notion for which activity theory is criticised. I will discuss this in section 3.5.1. This enculturation is not a passive process. The individual develops through effective participation in activities. In contemporary research (for example, Davydov, 1990; Rogoff, 1995) the term "appropriate" is used rather than "internalise" to emphasise the active role of the learner. I will expand on this in Chapter Three (sections 3.3.2.4 and 3.5.1).

Radical constructivism, developed by Von Glasersfeld, has been criticised for studying:

> human mental functioning as if it exists in a cultural, institutional and historical vacuum (Wertsch 1991, p. 2).

To its critics, radical constructivism presents a view of the human being as a closed system: “self-organising, self regulating, self-contained” (Kilpatrick 1987, p. 9). Communication is problematic in this approach with meanings “taken as shared” (Cobb, 1989) rather than shared. There have been attempts to integrate social aspects in accounts of the construction of mathematical knowledge (Restivo, 1992). These add on to radical constructivist perspectives by acknowledging the “important but secondary” place of social interactions in knowledge construction (Ernest, 1994, p. 66). Lerman (1994, 1996) argues that adding the “social” to constructivism leads to incoherence. It fails to account for how people understand each other, or to explain the social dimension in a personal world. Lerman (1966, p. 136) proposes that the Vygotskian approach presents a different world view to the mentalism that underlies constructivist thinking, one in which:

> it is necessary to recognize the shift from a view of the autonomous cognizing subject constructing her or his subjectivity and knowing to one of the construction of human consciousness in and through communication.

Hence, the difference in thinking between Piaget’s and Vygotsky’s followers does not simply lie in the latter taking greater account of social interactions, as social constructivists do, anyway. Rather it is in acknowledging the primary sense in which subjectivities and positionings are constituted and reconstituted by the social events and cultural history surrounding the individual. To activity theorists, socially and culturally linked goals and needs are seen as integral to cognition, rather than as the “interference” of subordinate issues (Lerman, 1996, p. 145).

Ernest (1994, p. 68) proposes that any form of constructivism retains portions of the radical constructivism metaphor of an:

> evolving and adapting, but isolated organism, a cognitive alien in an hostile environment.

Hence the individual's cognition takes place in a private domain of experience. Transference from the public or social realm to this personal domain cannot be explained. This problem is not, however, restricted to constructivism. Davydov (1991) an important student of Leont'ev, postulates that the structural difference between individual and collective activity is also an unsolved problem of activity theory. I will expand on this in section 3.5.1.

The two poles of thought represented by constructivism and Vygotskian approaches are major current theories which have in common a rejection of the transmission view of teaching and learning. They both focus on the actions of the individual in learning. Their points of difference have led to a multiplicity of models. Current approaches include: synthesising the two approaches (Confrey, 1991) superseding models (Steffe & Tzur, 1994) and emerging connectionist theories of cognition or enactivism (Bauersfeld, 1994; Varela et al, 1991). One example of a middle position between individualism and collectivism is an "interactionist" perspective (Bauersfeld, 1994, p. 139). It takes the position that the culture of the classroom is constituted in social interactions among teachers and students. Another strategy has been to adopt complementary perspectives (Bartolini Bussi, 1994). Bartolini Bussi (1994) argues that rigid adherence to the principles of constructivism or to a Vygotskian perspective does not recognise the richness and complexity of the ideas of the founders. Moreover she feels that theoretical coherence should not take precedence over real life problems. Indeed Bartolini Bussi (1994, p. 128) moves that such a pragmatic view is "deeply Vygotskyan", as Vygotsky himself was concerned with pressing social and cultural issues, rather than theorising. Lerman (1996) presents a critique of this view, arguing that adding bits of one theory to another, or slipping from one to the other, ignoring the contradictions, or plastering over theoretical holes in each, do not do justice to the insights and coherence of either.

As indicated above, there is considerable debate between protagonists of Vygotskian approaches and those of other current theories. I believe that the usefulness of activity theory lies in its systemic approach. Activity theory posits a view of learning in which personal experiences, goals, subjective perceptions and sociohistorical factors are interwoven. Rather than focusing on separate facets of learning and context, activity theory implies a commitment to investigating the learning process as a "dynamic system of meaning" (Vygotsky, 1962 p. 8) in which intellect and affect unite and through which society and the individual interact and evolve. This view of learning includes notions of growth and diversity.

2.4.3 Some Influences On The Theory Of Activity

In developing a Marxist psychology, Leont'ev drew on the work of many philosophers, such as Marx himself and Engels, and of psychologists, particularly Rubinshtein and, above all, Vygotsky.

Leont'ev's orientation to Marxism is a critical element in his theories about human consciousness and cognition. He explained the revolution brought about by Marx in the theory of cognition in terms of the role Marx ascribed to human practice in cognition (Leont'ev, 1978). That is, Leont'ev stressed that to Marx cognition and activity were inseparable. Leont'ev (1978, p. 12) wrote:

> In reality the philosophic discovery of Marx consists not in identifying practice with cognition but in recognising that cognition does not exist outside the life process that in its very nature is a material, practical process.

Leont'ev concurred with Vygotsky who was convinced of the Marxian concept that the "human essence is constituted by social relations" (Blanck, 1990, p. 45). That is, awareness, thought and other higher psychological functions, arise and develop in the interactions among people and their ties to the world in which they live. In Marx' philosophy, the object of knowledge is to transform the world, not just to understand it. In Soviet education, these ideas were translated into attempts "to construct a new socialist man" (Rosa & Montero, 1990, p. 82). Both Vygotsky and Leont'ev built their psychology on a conception of Man developed by Engels and Marx. This conception is expressed by Mellin-Olsen (1987, pp. 31-32) as follows:

> The conception is one of man as an acting person, at one time being both determined by history and determining it, being both created by society and creating it.

It was in this context of historical and dialectical materialism that Leont'ev considered activity as an object for psychology.

Leont'ev's formulation of activity owes much to his many debates with Rubinshtein. Rubinshtein, who lived from 1889 to 1960 explored the 'mind body' problem stressing that activity is not only external behaviour but is inseparably linked with consciousness. He expressed this in the formula:

> External causes act through internal conditions. (Leont'ev, 1981 p. 42).

Leont'ev disagreed with Rubinshtein in that the latter considered that practical activity was the subject of study for psychology only to the extent that such activity included internal mental processes, such as perception or thinking (Leont'ev, 1978; Gilgen & Gilgen, 1996). Leont'ev (1978) characterised this as a one sided view, in which mental activity is seen as directing physical activity, or external activity is viewed as dependent on psychological images. In Leont'ev's view, the "circle" of mental processes opens up "to meet" the external world of objects through external practical processes or activity (Leont'ev, 1978, p. 56). For example, bouncing a ball leads to a perception of its resilience.

To Leont'ev (1978, p. 56) the function of activity is "transforming this reality into the form of subjectivity". That is, activity enters psychology not as one of its elements, nor as an aspect of internal processes, but through its function — the function of linking the individual's external and internal worlds. At the early stages of its development, activity must have an external form. Activity develops through reflection and regulation. Through processes of interacting with others and the environment, mental images and thoughts take place. According to Leont'ev (1981, p. 52) these "deflect, change and enrich this activity".

Vygotsky's ideas and images permeate activity theory as a melody runs through a complex orchestrated score, with the harmonies, counterpoint, new melodies and even discordant notes, being provided by his students, mainly Leont'ev and Luria. It is therefore important for me to interpret Vygotsky's notions (Vygotsky, 1962, 1978) as they apply to activity theory in general and to my application of it in particular. My perspective on Vygotsky's ideas and their developments are developed in Chapter Three.

Vygotsky did not himself develop the concept of activity as a theoretical construct (Wertsch, 1981). However, he conducted empirical investigations based on the assumption of activity, emphasising the role of speech and semiotics in causing fundamental changes to the nature of the activity. According to Davydov and Radzikhovskii (1985, p. 53):

> the true methodological significance of Vygotsky's work consists of the assertion that activity is the explanatory principle in psychological theory.

This remark suggests that Vygotsky adopted Marx' approach to formulating a new psychology. Initially this was the case, as will be explained in the next chapter. In the last years of his short life, however, Vygotsky moved away from strict adherence to Marxist principles — at least this was the view of the Soviet authorities — resulting in his works being banned for many years in the Soviet Union. Some of Vygotsky's colleagues and students, including Leont'ev, went on to interpret and propagate Vygotsky's sociohistorical theory of psychology within a Marxist framework, linking individual consciousness and personality with social and practical activities.

2.4.4 Outline Of Leont'ev's Activity Theory

Wertsch, commenting on Leont'ev's exposition of the tenets of activity theory (in Leont'ev, 1981) summarises three major original contributions of Leont'ev to the works of Vygotsky and other theorists. The first of these is the construct of activity itself. Secondly, Leont'ev presents levels of analysis of human activity, arguing that activity can be viewed from the perspective of the milieu or context in which it takes place, from the goal directed actions which make up the activity and from the operations which depend on the conditions under which actions take place. Thirdly, Leont'ev replaces sign systems, which are central to Vygotsky's theories, with activity as the mediator between humans and their worlds. Thus an analysis of activity explains the dynamics of how humans relate to their physical and social environments. These ideas will be introduced in the sections below on activity, its structure and dynamics, and discussed further in Chapter Three.

2.4.4.1 Activity

Activity, as a construct, occupies a major explanatory role in the psychology that dominated the Soviet Union in the sixties and seventies. The very process of living is described by Leont'ev (1981 p. 46) as:

> the system of activities that succeed one another.

As described above, activity refers to the functional unit of human behaviour that relates the individual to his or her social and cultural world. Leont'ev and his fellow activity theorists explain that humans understand their world and develop knowledge about it by acting purposefully in it. In turn this activity changes the world.

Leont'ev rejects "positivist" (Leont'ev, 1981, p. 47) notions of activity which stress activity as purely adaptation to the external world. His main criticism of this perspective is that if psychology is limited to the concept of socialisation of individuals, the structure and transformations which link humans with their society will remain a mystery. To understand these links he posits that we must investigate activity — its structure, its specific dynamics and its various forms, both overt and cognitive (Leont'ev, 1981).

2.4.4.2 The Structure Of Activity

Leont'ev (1981) identified three levels of analysis of activity. Further expansions were provided by Zinchenko and Gordon (1981).

- The first level is concerned with the global aspect of activity. This defines activity as a unit of life mediated by reflection; a frame outlining the context in which the activity takes place, for example, play, formal education or work. This level identifies the socioculturally defined milieu in which the actions occur. At this level analysis is therefore concerned with the motivation underlying and engendering the actions, the "energising function" (Leont'ev, 1981, p. 60) of the activity.

- The second level relates to the actions which make up and realise the activity: how the task was carried out. To Leont'ev, actions are always directed toward a goal (Leont'ev, 1978, 1981). He did not acknowledge that we sometimes do things without a conscious reason. He postulated that there may be many intermediate or partial goals to be satisfied on the way to achieving the final aim. These intermediate goals are determined consciously and with regard to the social relations in which they are set. Leont'ev (1978) gives the example of individuals beating the bushes to scare out an animal which will be caught by other, strategically placed, members of the community. The actions of beating the bushes do not in themselves have direct relevance to satisfying hunger, the motive of the activity. It is the connection of these actions to those of others and to the main purpose of the exercise which explain the actions.

As outlined by Leont'ev (1981) actions have an intentional aspect (what must be done to reach the goal) and an operational aspect (how it is done) and these are carried out to realise a conscious motive. The same motive can give rise to different goals and accordingly can produce different actions. Conversely the same actions can realise different activities. For example, a statistical procedure such as a "t - test" may be carried out by a student to get an answer, with little reflection about understanding the procedure (a processing activity) while different goals may lead to the same actions being carried out but with the focus on the underlying rationale of the procedure (a learning activity).

- The means by which actions are carried out are labelled operations by Leont'ev (1981). Operations are therefore components of actions. While actions are determined by the goals which they fulfil, operations depend on the conditions, especially the tools, which delineate the exact mechanisms for carrying out the action. Tools can be physical, or "extra-cerebral" (Leont'ev, 1981, p. 64) for example, computers or calculators for carrying out statistical procedures. They can also be cognitive, for example an algorithm, followed mechanically in order to get a result. Leont'ev (1981, p. 64) posits that it is the fate of operations to become automatic by their mechanisation (he calls it "technicalization"). Operations, however, are inseparable from the actions and in turn the goals which they serve. They are under conscious control as part of the actions and, through these actions, the activity in which the individual is engaged. The issue here is that different conditions lead to different compositions of actions. Solving a linear algebraic equation, for example, may be performed on an operational plane if the student has practised the process many times but not if the student is a novice in algebra. This level of analysis is particularly pertinent to the analysis of learning Statistics where the aim of many students is to become familiar with, and so automate, processes and algorithms.

The implication of viewing activity from different levels is that these provide different vantage points for investigation. At the global level, Leont'ev (1981) distinguishes activities on the basis of motive and the object toward which they are oriented. This provides one vantage point from which to understand students' learning. Activities are comprised of actions which are determined by the goals impelling them. Hence the conscious goals or needs driving the actions provides another perspective for analysis. Actions, in turn, consist of operations where the notion of operation has to do with the routine automatic aspects of carrying out a task. (Wertsch's note in Semenov, 1978, p. 44). This level of analysis, therefore, relates to the means or resources for carrying out the actions.

2.4.4.3 Dynamics

To Leont'ev, the problem of understanding the dynamics of activity, is one of discovering the relationships that connect the individual's behaviour with physiological functions, "the work of the brain" (Leont'ev, 1981, p. 67). By this, Leont'ev is not proposing a quick course in neuro-physiology. Rather he suggests an indirect approach — investigating the functional development of the mechanisms in the brain as a product of activity. This analysis must include an understanding of both phylogenetic development, that is, development which is sociohistorical or evolutionary, and ontogenetic development — the maturing of the organism. Leont'ev posits that higher order mental functions take place as a result of "mastering tools (means) and operations" (Leont'ev, 1981, p. 67). These mental systems are instated by or generated by activity. This means that mental images are not formed by the brain; they are the function of the brain. They are generated in the transition from the "extracerebral to the intracerebral sphere" (Leont'ev, 1981, p. 69). That is, there is no landing pad in the brain awaiting the arrival of images. It is by means of our actions, including mental actions such as reflection, that we transfer images from the external world to the cognitive sphere. Activity mediates between the environments surrounding humans and our internal domains.

Leont'ev (1981) stresses that activity is characterised, not by its units (actions and operations) which are meaningless if studied in isolation, but by the systemic connections between the units and their transformations. That is, activity is not simply a sum of actions. Rather, the connections between the parts and the goal formation determine activity. The levels of activity are mobile or dynamic; actions can become activities in their own right. For example, driving a car is an activity if the person is learning to drive in order to pass a driving test. It is purposeful, effortful action. The same actions — such as steering, braking, accelerating, may, however, be carried out as part of another activity, for example driving to work. Here the setting is work; the partial goal of the driving actions is to arrive at work — actions such as steering or braking, are the means of achieving this aim. Further, if the driver is experienced, the actions taken in driving may be automatic. They are now operations. However, in a difficult situation, such as a driver would experience in heavy traffic and wet conditions, conscious decisions will again regulate the actions, rather than a mechanical set of operations being performed.

The above example illustrates that in the course of attaining an overall goal, activity may be split up into separate, successive actions which are consciously carried out with the help of operations which, in turn, may have been formed under different circumstances. The opposite happens when the individual is no longer conscious of intermediate results — the overt actions and mental reflection merge together or are consolidated in carrying out an activity. According to Leont'ev, investigating both these aspects: the breaking down of the activity and the integration of its actions and operations, can only be done by studying the links. These may be all internal, as in cognitive activities, but, more often, internal activity is implemented by external actions.

The word "activity", as used throughout this thesis, refers to this framework. That is, a student's statistical activity encompasses her actions within a specific context, her goals, (for example, she may be analysing data to arrive at a result or to understand the process underlying the analysis) and the resources available to her, whether technological or her own expertise.

2.5 THE ACTIVITY OF LEARNING STATISTICS

While activity may be viewed as an abstract construct, Leont'ev (1981) emphasises that in reality we always deal with specific activities, within a finite time, space and setting. His three levels of analysis provide three vantage points on a fundamental question for any investigation from the perspective of activity theory: the question of what an individual or group is doing in a particular setting.

In order to understand what a particular group of students is doing in learning Statistics, responses can be formulated in terms of each of these three levels. The first level concerns the cultural or historical milieu of the students' actions. This is an account of students' learning from the perspective of the global level of activity. To respond to the question at this level it is necessary to understand students' actions in the institutional context — while studying a university course.

A university has its own well defined social practices. Students' interpretations of these practices are bound up with their perceptions of what is expected of them and will be fundamental to their actions. According to Wertsch (1985, p. 212):

> An activity setting is grounded in a set of assumptions about appropriate roles, goals and means used by the participants in that setting.

This setting guides the selection of actions and choice of tools. It also determines the function of the activity. Wertsch (1985) explains that settings are not determined by the physical context but are created by the participants in the activity. Further, assumptions about the setting are often implicit, rather than consciously identified. Participants may not identify what organises their performance. An individual's understanding of the setting emerges as a "by-product" of interacting with others in it. (Wertsch, 1985, p. 216).

To say that a student is engaged in the activity of learning a university subject, Statistics, simply tells us that the student is working in a particular socioculturally defined setting. To understand activity at Leont'ev's second level of analysis (Leont'ev, 1981) one must look at the actions which, in his view, are defined by goals or partial goals. In my view, goals are not automatic nor fixed in advance. They are tested by action and remain fluid throughout the process of selection and testing. This notion of goals as in flux — as being socially tested hypotheses — was expressed explicitly by one student whom I interviewed during her first year at university.

> I've never really studied before this at all, and it's only been since last year that I actually applied myself to anything in academic terms. And so for me everything's just — what's the word ... an experiment. An experiment to see what works and what doesn't.

Finally, a response to the question about a student's learning of Statistics can be formulated in terms of the tools and operations that the student has at her command. This is the third level of the activity of learning Statistics that must be investigated. The availability of tools as mediating devices will partly be determined by the setting — for example what calculators are deemed appropriate for students to use. Tools and operations also depend on the student's personal history — her experiences, including the student's repertoire of skills, such as her ability to use a calculator or mathematical symbols. Affective elements are important as well. If the student's memory of using a compass at school is linked to negative emotions, this tool will not be readily utilised. The tools or operations used by a student affect how successfully the student is able to carry out her intentions.

2.6 FRAMING THE RESEARCH QUESTION

Guided by activity theory and within the methodological framework outlined, I explore the qualitatively different ways students relate to their learning of a statistics course at university. As I specified in Chapter One, Statistics, with a capital "S" refers specifically to the statistics component of the Psychology II course. Hence this usage immediately specifies the setting of the activity as university learning of a particular topic at a defined time and place.

The main research question which I investigate is:

What are students' orientations to learning Statistics ?

I am interpreting the word "orientations" as signifying students' positioning of themselves with respect to the learning task. This question is important because, from the theoretical perspective I have outlined, students' orientations to learning Statistics are integral to the ways students engage with the learning task and hence relate to the quality of their emerging knowledge.

To investigate the research question I explore three interdependent aspects. Firstly, I investigate different facets of students' orientations to learning Statistics, including affective elements, students' conceptions of Statistics and their approaches to learning the subject. Secondly, I look at the connections between students' orientations to learning Statistics and the outcomes of learning it, mediated by their activities. Thirdly, investigating this question intrinsically includes exploring the relationships between the students' perceptions and actions and the contexts surrounding their learning. For example, if a student's conception of Statistics is "algorithms", this is not a characteristic of the student or of the subject Statistics or of the educational institution. It is a relationship between the student's way of experiencing Statistics and the contexts surrounding these experiences. From the activity perspective, how a student orients herself in the learning arena (Lave, 1988) her actions and her evaluations of the learning task, develop together and coherently and, with their accompanying outcomes, are organised within and contribute to the wider sociocultural setting.

A student's orientation to learning Statistics could be regarded as a particular mind set individually generated in response to her experience of a certain context. My view of orientation is in contrast to this view of it as an individual and internal construction. Consistent with an activity theory framework, I regard a student's orientation to learning Statistics as inseparable from her actions to learn Statistics and as part of a wider and dynamic societal "system of activities" (Leont'ev, 1981, p. 46). Statistical thinking cannot occur in isolation, in the head. In learning Statistics, an individual is participating in a cultural practice even when she appears to be acting in isolation, such as doing examples or reading a text book. Further, the statistics (as a generic term) that the student is studying has itself developed historically through interactions which are culturally founded. The methodology for statistical inference, for example, has been cultivated and improved by successive generations and continues to undergo major transitions as a result of current technology.

My interpretation of the activity of learning Statistics, drawing on Leont'ev's (1981) sense of the construct, refers to the actions a student takes to grapple with it — to engage, purposefully, with the problem of learning it. A student's engagement with the task of learning Statistics is expressed by both cognitive actions and practical actions. These actions are directed, not random, even if the student does not articulate her goals. By "doing" Statistics a student "makes" it "artistic, practical, creative or routine", as was expressed by the student quoted at the beginning of this chapter.

2.7 CONCLUSION

The literature on statistics education shows a great concern for improving teaching. My way of approaching this problem is to try and increase understanding of how students learn Statistics. In this chapter I have introduced Leont'ev's theory of activity and my application of it to this understanding. In summary, I propose that students learn through their actions in context. That is, my interpretation acknowledges that learning Statistics is a human activity that occurs in a social, cultural and historical context. These ideas will be developed in Chapter Three.

My perspective stresses the changing and fluid course of a student's statistical thinking — actions realise the emerging statistical knowledge. Moreover, the meaning of Statistics to the individual does not produce her statistical thinking — it mediates her thinking in the same way as tools mediate rather than produce changes in the environment.

CHAPTER THREE

ACTIVITY THEORY: A PERSPECTIVE ON LEARNING

3.1 INTRODUCTION

3.1.1 Chapter Preview

In this chapter I review the literature interpreting Vygotsky's approach and Leont'ev's modifications of his ideas. I try to give a range of perspectives on their theories by including the views of contemporary Russian theorists, such as V. V. Davydov and V. P. Zinchenko, and some well known Western scholars, such as J. V. Wertsch and J. Valsiner. To clarify my underlying theoretical position, I differentiate between theoretical approaches which are framed primarily in terms of Vygotsky's concepts and those which take the viewpoints of Leont'ev and his colleagues in the Khar'kov school.

Initially, in sections 3.1.2 and 3.1.3, I explain the background to my literature review and to my application of activity theory. In section 3.2, I explain some important ideas of Vygotsky, particularly the cultural historical theory and other aspects of his framework associated with this theory. In 3.3, I develop the tenets of the activity theory approach: its historical emergence, its features and its principles and how these ideas are understood in contemporary research and education. I illustrate aspects of this theory with examples from my practice in section 3.4. These examples suggest that activity theory has important implications for education research and for understanding students' learning in practice. In section 3.5, I comment on unsolved problems of the theory and some contemporary derivatives of the theories of Vygotsky and Leont'ev. I conclude, in section 3.6, by explaining the relevance of the theory to my investigation — how my approach builds on notions of activity theory and where it departs from these ideas.

3.1.2 Background To Literature Review

Activity theory, in the view of Engeström (1993, p. 64) "is one of the best kept secrets of academia". Engeström speculates that this is partly due to language difficulties, in part because of the epistemological roots of the theory in German philosophy and dialectics and also due to the complex and "impressive" theorising behind the activity approach (ibid, p. 64). Yet this theory is unquestionably evolving in Western thought as well as in its birthplace and has shown itself to have considerable implications for practice and research.

In this chapter I develop the theoretical framework introduced in the previous chapter. I review the principles of activity theory as they have been explored in the literature. Activity theory has been interpreted differently in different countries and at different historical periods. For instance, the translation of the original Russian scripts into various languages communicates different nuances of the theory. For example, the German word, "Tätigkeit", evidently conveys a sense of serious purpose, such as work activity or occupation, which is lacking in the English word, activity. Clearly, too, the perspectives of those who look back at a theory, which emerged in a period of tremendous turmoil and social change, will differ from the perspectives of those who wrote while they were embroiled in the events. Finally "theories in 'use' are always theories developing" (Bauersfeld, 1994, p. 133).

I have tried to piece together current interpretations of activity theory and its recent developments from the latest English publications available in Australia. The fact that a number of these scholarly works have been published since 1990 is an indication of the ongoing interest in activity theory and its relevance.

In Western education, the focus of the contemporary activity approach is on two major and related strands. One aspect pertains to the emphasis on goal driven actions as central to a student's learning. This aspect relates to Leont'ev's construct of activity. Secondly, based on Vygotsky's expositions, which are more familiar to Western educationalists, current approaches stress the cultural, historical and social base of these actions as being germane to the learning that takes place. My aim in this chapter is to show how these cornerstones of the contemporary activity approach were developed in the work of Vygotsky and re-interpreted by Leont'ev and other of Vygotsky's colleagues and students. To begin with, in section 3.1.3 below, I expand on my interpretation of students' learning of Statistics, taking aspects of activity theory as my starting points.

3.1.3 Using The Lens Of Activity Theory To Understand Students' Learning Of Statistics

In Chapter Two, I outlined my approach stemming from my belief that a student's learning proceeds through her active engagement with the task within a social and cultural setting. This draws on Leont'ev's notion of activity as "a system in the system of human relations" (Leont'ev, 1981, p.47).

A focus on learning as activity which is socially and culturally situated is bound up with exploring what Varela et al (1991, p. 213) term "histories that are lived". Leont'ev (1978) elaborating on Vygotsky's ideas, distinguished between three kinds of histories that are lived — evolutionary, societal and individual histories. Firstly, evolutionary history has resulted in humans having bodily structures which enable us to interact with the world. This physical structure outlines the essentials of human existence. Secondly, from a societal perspective, the embodied person is spatially and temporally situated. The self speaks "not only as an individual voice but also as a collective voice", reflecting values and beliefs of communities and cultures which are significant to the individual (Hermans & Kempen, 1995, p. 112). Finally, each person develops a personal story, a history of her own experiences which have left their mark. These three histories that are lived, act in tandem in human activity — such as the activity of learning Statistics. The actions a student takes to learn Statistics involve that student's cognitive abilities, which have developed over the history of the human race — her evolutionary history. This history is inseparable from the development of tools, language and other cultural means of mediation. Secondly, a student's activity is related to her situation in an institutional and societal setting. Thirdly, and interwoven with these other histories, is the personal narrative of the student, both her biological and social development, which contributes to her ways of understanding Statistics and of interpreting the context in which she encounters it.

A key argument of activity theory is that personally meaningful goals have an "energising" function (Leont'ev, 1981, p. 60). Varela et al (1991) specify two aspects of goal directedness or intention. These correspond to (p. 206):

> what the system takes as its possibilities for action to be and to how the resulting situations fulfil or fail to fulfil these possibilities.

In my investigation, this means that actions taken to learn Statistics are directed by how the student construes her goals in context. In turn, how these goals become fulfilled, or fail to become fulfilled, is affected by the conditions surrounding her actions.

Goals, with accompanying evaluations, are interpreted within an institutional and broader cultural location. Hence the principle that learning is purposeful, or goal driven, links the two aspects of activity theory that I have delineated — the sociocultural situatedness of activity and the directed actions comprising the activity.

In summary, interpreting a student's learning from the activity perspective means attending to the "system of activities" (Leont'ev, 1981, p. 46) or practices in which the student is engaged and understanding how the student is oriented or positioned with respect to these particular practices. Evans and Tsatsaroni (1994, p. 172) describe the positioning of a student engaged in a learning practice as (their emphasis):

> the resultant of the practice(s) in which all subjects in that situation *are positioned*, and of the practice(s) which the particular subject *calls up*.

This implies an operative interplay between participants and setting.

Further, Evans and Tsatsaroni (1994) argue that there are critical aspects that make the practices, in which students are engaged, meaningful. These include: the students' goals; the resources available and the constraints confining the students; the social relations, including the exercise of power on which these relations are based and the "discourses which shape the practices themselves" (Evans and Tsatsaroni, 1994, p. 169). Their argument is based on suppositions which include both Vygotskian notions, such as the importance of speech and interpersonal relationships, and Leont'ev's emphasis on the goal directedness of all actions and on the conditions which determine the operations (Vygotsky, 1962; Leont'ev, 1981). Hence it is important for me to explain the roots of these ideas, and the others I have outlined, in Vygotsky's and Leont'ev's theories.

3.2 AN INTERPRETATION OF VYGOTSKY'S LEGACY

3.2.1 Background

Vygotsky, as he would have been the first the admit, was a product of the culture and history of his time. Born in 1896 to a middle class Jewish family in a provincial Russian town and living only until 1934, he was an intellectual, moving comfortably from the realms of art and literature to science and psychology. In Russian culture at the time there were no sharp divisions of labour among science, art, philosophy, literature and even theology. Scholars such as Vygotsky were simultaneously "connoisseurs of these spheres of human activity" (Zinchenko, 1995, p. 37).

Vygotsky was greatly influenced by philosophers, scientists, psychologists and writers: Spinoza, Hegel, Engels, Köhler, Freud, Piaget, Shakespeare and the poet Mandelshtam, to mention but a few (Vygotsky, 1962, 1978). The teachings of Marx and Engels had a profound effect on his thinking. Unlike many of his colleagues and followers, however, he did not reify Marxism, and ultimately did not accept that Marx' theory provided the explanatory principle of psychology. This led to his falling into disfavour with the authorities towards the end of his life. His works were banned, some posthumously, and much of his later and most important writing was only published in Russia more than twenty years after his death.

Vygotsky saw psychology as experiencing a crisis which was both deep and global. In his view this was a methodological crisis, stemming from the contradiction between the factual material of science and its theoretical premises. He stated that:

> As long as we lack a generally accepted system incorporating all the available psychological knowledge, any important factual discovery inevitably leads to the creation of a new theory to fit the newly observed facts (Vygotsky, 1962, p. 10).

He tried to resolve this crisis by seeking a means of analysis specific to the field of psychology — a systematic way of organising the content, and delineating a framework for psychology. To Vygotsky:

> 'general psychology' (or the 'dialectics of psychology,' as he also called it) has its own laws, forms and structures (Yaroshevsky, 1996, p. 169).

In his, ultimately unsuccessful, search for the ideal analytic method, Vygotsky became inspired by Marx' analysis of political economics. In the atmosphere of the early 1920's in Russia, there was a struggle between psychology, which used introspective methods and focused on the inner world of the individual, and the study of physiological processes, such as reflexology. According to Vygotsky (1962, p. 95):

> Reflexology, which has translated associationism into the language of physiology, sees the intellectual development of the child as a gradual accumulation of conditioned reflexes; and learning is viewed in exactly the same way.

Vygotsky was critical of this reduction of psychological processes to reflexes of various complexities. Reflexology and its opposing physiological theory, reactology, which was formulated by Kornilov and proclaimed the reaction as the basic unit of psychology, threatened to sweep away "subjective, empirical psychology", as it was then in Russia (Yaroshevsky, 1996, p. 165). Marxism was seen by Vygotsky as the saviour of Russian psychology. However, he had his own perspective on Marxism. Vygotsky stressed that scientific truth concerning the mind was not a monopoly of Marx and developed his theories in dialogue with Marxism. This approach differed heretically from ideologically approved perspectives and publications of the time (Yaroshevsky, 1996).

Vygotsky's short life span, ill health and prodigious talent meant that, although he espoused many ideas, these did not represent a complete psychological system — they expressed an approach rather than a solution to the problems of psychology (Van der Veer & Valsiner, 1991). Van der Veer and Valsiner (1991) point out that the very lack of conclusion of Vygotsky's theories makes them useful for modern researchers who can develop them in their own settings. Today, there are many theoretical expositions which extend Vygotsky's ideas. For example, there is considerable research on how cognition develops in social practice, such as Scribner's extensive work (reviewed in Tobach, Joffe Falmagne, Brown Parlee, Martin & Scribner Kapelman, 1997); research on situated learning in the form of legitimate peripheral participation (Lave and Wenger, 1991); on the role of signs as mediators of cognition (for example, explorations of semiotically mediated meaning-making in mathematics learning in Vile & Lerman, 1996) as well as "sociocultural" studies (in Wertsch, del Río & Alvarez, 1995). Indeed, Van der Veer & Valsiner (1991, p. 373) contend that:

> the theoretical debate about the validity and fruitfulness of Vygotskian ideas is only at its very beginning.

In the West, the focus of recent research in education has been on a small selection of Vygotsky's concepts from the plethora of ideas he expressed. This is not surprising in our time of increased specialisation in areas of study. For example, Vygotsky is described by Wertsch et al (1995, p. 6) as a "psychologist, semiotician and pedagogical theorist". These areas are usually considered quite distinct in contemporary Western disciplines. Also, some of the research work done by Vygotsky and his colleagues and students has been criticised as inappropriate for our political and temporal era. For example, one claim ascribed to the cultural historical school is that contemporary aboriginal peoples are similar in development to primitive peoples of the Prehistoric era. This criticism refers to studies carried out on so-called primitive peoples in Central Asia by Vygotsky and his close associate, Luria, an important Soviet psychologist. Whether Vygotsky held that view in this simplistic way is, however, considered controversial (see Scribner's views in Tobach et al, 1997). One interpretation (Wertsch et al, 1995, p. 7) is that Vygotsky considered the "huge wealth of vocabulary" of these rural people to be an impediment to their developing psychological tools. Such tools were, however, needed for the development of technology by cultural groups who had less abundant language. More importantly, such criticisms miss the point of Vygotsky's underlying thesis and its great strength — that psychological processes are not racially innate, or formed in the individual's head, in isolation, but develop in the cultural milieu of the individual. Luria & Yudovich (1959, p. 15) express this idea strongly in their promotion of Vygotsky's approach as follows:

> Only by understanding that the sources of all complex mental processes do not lie in the depths of the soul, but are to be found in complex forms of human social life and in the child's communication with people surrounding him, can we finally outgrow the prejudices which have been rooted for centuries in psychological science.

In contemporary education literature, Vygotsky's contribution concerning the importance of culture to formal or school learning is increasingly being recognised (see, for example, Cole, 1995a).

In what follows, I will interpret some of Vygotsky's ideas, which are relevant to my approach. An important and fundamental aspect of Vygotsky's reasoning is his dialectical thinking. Based on Hegel's philosophy, dialectical thinking involves the resolution of disconnected or mutually discordant points of view — it is a rational method of synthesising conflicting ideas. To Vygotsky, opposing points of view meant that problems were being subsumed. These, in resolution, would lead to new insights. Van der Veer & Valsiner (1991, p. 390) argue that:

> the over-riding concern evident in Vygotsky's intellectual work is the quest for synthesis.

Hence, though presented separately, Vygotsky's insights, described in section 3.2.2, below, are interdependent.

3.2.2 Some Of Vygotsky's Insights

3.2.2.1 Human Evolution As Cultural-Historical Development

Perhaps the most well known contribution of Vygotsky to modern thinking in the West is his emphasis on the "historical development of humans" (Vygotsky, 1978, p. 60). This "cultural historical theory", in summary, suggests that human higher processes developed in human history and have to be learnt anew by each child by means of social interactions (Van der Veer & Valsiner, 1991; Wertsch, 1985; Zinchenko, 1995). Vygotsky accepted Darwin's idea that the evolution of man from animals was a continuous process. In marrying Darwin's evolutionary theory and the Marxist concept that Man has control over his own economic destiny, Vygotsky interpreted the continuity of biological evolution and cultural human development in a dialectic way (Vygotsky, 1978). That is, he believed that the qualitative differences between humans and animals — the development of higher mental abilities — arose in a complex interaction and antithesis of biologically produced, genetic factors and social interaction. However, he assigned the major role in the development of particularly human traits to the mastering of culture, particularly the mastering of cultural artefacts such as sign systems and speech. For example, Vygotsky (1962) proposed that children's intellectual growth was contingent on their mastering the social instrument of thought, speech — via inner speech. He called socially developed thought: "verbal thought", which he explained as follows (Vygotsky, 1962, p. 51):

> Verbal thought is not an innate, natural form of behaviour but is determined by a historical-cultural process and has specific properties and laws that cannot be found in the natural forms of thought and speech. Once we acknowledge the historical character of verbal thought, we must consider it subject to all the premises of historical materialism, which are valid for any historical phenomenon in human

> society. It is only to be expected that on this level the development of behaviour will be governed essentially by the general laws of the historical development of human society.

That is, complex processes such as thinking have their bases in the sociohistorical development of human society.

To Vygotsky, following Engels' writings, history is the history of cultural artefacts which allows humans to control their own environments. These cultural means, as they are mastered by the developing child, change not only the content of the child's thinking but the very way of his thinking. This means that growing into a culture — appropriating its means — creates in the child a "second nature" (Van der Veer & Valsiner, 1991, p. 225). To Vygotsky and his colleague Luria, this adopting of cultural modes was not like putting on clothing, because cultural layers, once taken on, cannot be shed (Vygotsky & Luria, 1930, quoted in Van der Veer & Valsiner, 1991, p. 225). For Vygotsky, who ignored learning at home as informal learning, the means by which this enculturation takes place is education (Vygotsky, 1962; 1978). His empirical studies focused on children's acquisition of "scientific concepts", that is, abstract or generalised concepts and looked at "the interaction of development and instruction" (Vygotsky, 1962, p. 117). Vygotsky's view of a rational man, one who is in control of his intellect and behaviour, was that he is an educated man — where education is the process of mastering the means provided by the culture.

Vygotsky's definition of culture was selective, emphasising those aspects of human life which enable people to control their environment, such as tools and communication systems — by means of which productive labour is possible (Van der Veer and Valsiner 1991). This was not because Vygotsky lacked interest in aspects of human evolution such as wisdom, music, or creativity. Initially at least, he was inspired to frame his thinking in Marxist terms. Hence the idea of the tools of labour as the means by which people collectively master the physical world and gain economic power, influenced his thinking. The idea of mental tools developed from this notion of man using physical tools to conquer his own destiny. Vygotsky saw signs, for example, words and symbols as analogous to tools in mediating thinking. Van der Veer & Valsiner (1991) suggest, too, that Vygotsky would have seen little evidence for progress in areas of social evolution, such as wisdom or creativity. On the other hand, technological artefacts and communication systems — language, writing and symbols — were transforming the ways people functioned. Hence a focus on these "hard" aspects of cultural development was consistent with Marx' and Engels' characterisation of human qualities as dependent on mastering tools. It was also consistent with Vygotsky's "sincere wish" to liberate and improve the quality of life of all citizens (Van der Veer & Valsiner, 1991, p. 214). By having access to education and the mediational means it provided, people could progress in their thinking and so, in Vygotsky's view, free themselves from the yokes of feudalism.

It is possible that a nucleus of Vygotsky's theory of cultural transmission can also be found in his own, absorbed, religious heritage. Vygotsky's religion, Judaism, is rich in symbols and rituals. Further, each symbol, which is adopted by the community, and each ritual in which the community participates, contains the history of the Jewish culture. Also, each shared ritual and cultural symbol or artefact, is itself the seed of continuity — a means of passing on the history and culture from one year to the next, from generation to generation. This is precisely the point of Vygotsky's theory of cultural historical transmission.

3.2.2.2 Developmental Explanation Of Human Mental Processes

Vygotsky's stated aim (Vygotsky, 1962; 1978) was to achieve a complete and dynamic analysis of higher psychological systems: their development, their structures and their functions. He differentiated between the maturation of basic biological functions and the development of higher mental facilities as follows (Vygotsky, 1978, p. 46):

> *Within* a general process of development, two qualitatively different lines of development, differing in origin, can be distinguished: the elementary processes, which are of biological origin, on the one hand, and the higher psychological functions, of sociocultural origin, on the other. *The history of child behaviour is born from the interweaving of these two lines.* The history of the development of the higher psychological functions is impossible without a study of their prehistory, their biological roots, and their organic disposition.

So, in order to explain, rather than merely describe, mental processes, Vygotsky insisted that their origins must be examined: phylogenetic (evolutionary, lineage); ontogenetic (developmental); microgenetic (development over a short time). Scribner (1985, p. 120) asserts that to Vygotsky:

> the historical research of behaviour is not an additional or auxiliary aspect of theoretical study but forms the very basis of the latter.

Vygotsky tended to use the terms cultural and historical interchangeably and expressed a need to search for explanations of human behaviour, as opposed to that of animals, in history rather than biology. In his view, higher mental functions are collectively produced and have a sociohistorical, rather than biological, origin. So for phylogeny, the cultural development displaces the biological, that is, the "social" line takes over (Vygotsky, 1978). The biologically derived term "ontogeny" is used by Vygotsky as a generic term to refer to all processes of child development, so that in his work the concepts of the cultural and the biological development of the child are fused. According to the Vygotskian perspective, language is the main agency by which society changes biological development to social progress (Vygotsky, 1962, 1978, 1981a).

Vygotsky's understanding of history, both societal history and child development, was not a simple account of universal and linear progress. Rather, he recognised historical processes as changes that move humans in many directions and on many levels. Vygotsky proposed that the relationship between revolution and evolution, though not universally recognised, is understood in scientific thinking. He expressed this as shown below.

> To the naive mind, revolution and evolution seem incompatible and historic development continues only so long as it follows a straight line. Where upheavals occur, where the historical fabric is ruptured, the naive mind sees only catastrophe, gaps, and discontinuity. History seems to stop dead, until it once again takes the direct, linear path of development.
>
> Scientific thought on the contrary, sees revolution and evolution as two forms of development that are mutually related and mutually presuppose each other (Vygotsky, 1978, p. 73).

Vygotsky's understanding of the relation between history as change and history as unilateral progress is less clearly demonstrated in the work of Vygotsky's students and followers (Wertsch et al, 1995).

As outlined, Vygotsky's theories (1962, 1978) are a powerful lens for viewing the development of the child. His basic claim was that there are two lines of development in the child. One is the biological growth and maturation of the child. The other, which guides the first, is the mastering of cultural artefacts, particularly speech. The child develops through the internalisation of activities carried out while interacting with others, usually adults. This theme has its roots in the work of Marx as well as taking account of the work of important psychologists of the time, including Piaget and Janet (Wertsch, 1990; Yaroshevsky, 1996).

3.2.2.3 Origins Of Higher Mental Functions In Social Life

The theme described above — that mental functions emerge from shared social experiences — is formulated by Vygotsky's explanation that a child's development appears first on the social or interpsychological plane then on the personal or intrapsychological plane (Vygotsky, 1962, 1978, 1981a). That is, Vygotsky proposed that every higher mental function, as it develops in the individual, goes through an external stage in its development because it is initially a social function. In particular, adults' verbal interactions with the child underlie higher functions, such as voluntary attention or concept formation. According to Vygotsky (1981a, p. 162):

> We could therefore say that it is through others that we develop into ourselves and that this is true not only with regard to the individual but with regard to the history of every function.

Vygotsky (1978) described four major stages in the child's developing cognitive processes. These were based on his empirical studies of children carrying out various experimental tasks. In the first stage the child responds to the immediate stimuli around him and his own basic needs. The beginnings of mental mediation arise in the second stage when the child, instead of solving a problem impulsively:

> now solves it through an internally established connection between the stimulus and the corresponding auxiliary field (Vygotsky, 1978, p. 35).

At this stage, however, the child has not fully mastered the means of mediation. The third stage is reached when the child becomes aware of the role and utility of the mediator in cognitive activity. For example, in one of Vygotsky's experiments, children use pictures to decide which keys should be pressed to fulfil a given task. At this stage children can organise their environment but their regulation of their own behaviour is still dependent on the stimuli present in the external environment. The final stage in the development is characterised by the internalisation of the words or other signs and the relationships among the stimuli, mediator and responses. The operations can now be carried out without external stimuli.

To me, the most important point about Vygotsky's account of this progression to self regulation is his emphasis that this is a social process. Díaz, Neal & Amaya-Williams (1990) specify four ways in which this is so. Firstly, the signs and tools that are brought to the setting, and are taken over by the child to control his or her behaviour, are social. They are features of the society or culture at large. Vygotsky (1981b, p. 137) gives many examples of "psychological tools" used in this way, including:

> language; various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes; diagrams, maps, and mechanical drawings; all sorts of conventional signs.

Secondly, these signs are used by the child to influence others and interact with them — they have an immediate social role. Thirdly, in Vygotsky's view, speech is the most useful agency by which children master their environments. Speech is inherently social — it carries shared meanings with others in a particular setting. Speech not only mediates social interactions, but is also a tool for planning, organising and monitoring behaviour (Vygotsky, 1962). The child's symbolic activity, especially private, internal speech allows the child independence from the external stimuli and enables mastery over her own responses. Vygotsky (1962, pp. 121-122) expressed the evolution of "verbal thought" from simple generalisations to the most abstract concepts in this way:

> It is not merely the content of a word that changes, but the way in which reality is generalised and reflected in a word.

So the use of language and other semiotic systems transforms thought in ways that connects the child to her social environment. These transformations are not only in what the child thinks but also in the way she thinks. For example, the strategies people use to solve problems, the categories through which they organise their experiences and the ways people express themselves in language, depend on their cultural history and society.

One of the mechanisms by which Vygotsky (1978) explained how individuals realise their potential is his construct of the zone of proximal development. This relates to Vygotsky's aim of empowering people through instruction (Van der Veer & Valsiner, 1991). It also draws on the Marxist notion that individuals can shape their worlds and develop their higher mental faculties through cooperating and interacting with others. Referring mainly to children, Vygotsky (1978) defined this zone as the area between what a person can achieve on her own and what she can achieve with the help of a more capable person. This emphasises the child's potential to develop with strategic help. This support is called scaffolding by some researchers, following Bruner (1985) emphasising the support given to the learner. It is termed amplification by others (from Zaporozhets' term, cited in Bodrova & Leong, 1996, p. 41) which focuses on the child's own potential and current strengths.

The implication of the zone of proximal development is that the inexperienced learner will in the near, or proximate, future master a task for which she currently requires some help. Vygotsky chose the word "zone" to underscore the idea that development is a "continuum of behaviours" not a point on a scale (Bodrova & Leong, 1996, p. 35). The zone of proximal development has a dynamic nature. As the child masters new and more difficult tasks, the zone of proximal development shifts, and the cycle of assisted learning followed by independent achievement is repeated. This notion of Vygotsky's is well known and has been extensively researched in the West (for example, in Bodrova & Leong, 1996; Moll, 1990; Newman, Griffin & Cole, 1989; Rogoff, 1986). It has important implications for mathematics and statistics education where, often, the focus is static — on what students can do unaided at a point in time — the lower boundary of the zone of proximal development. There may be little focus on the continuum of students' skills and abilities or on their potential to progress by means of structured interactions. Traditional assessment in mathematics and statistics reflects the view that a student "knows" or "does not know" a particular concept. Vygotsky's idea of a concept is dynamic. In his term a concept is a maturing process, rather than a mental acquisition.

Vygotsky's perspective recognises the primacy of social contact as a basic human need and also rejects the dualism between the individual and society, insisting on the inseparability of the individual and the social realm in which she acts. The application of these ideas is well documented in the work of contemporary researchers such as Lave & Wenger (1991); Rogoff (1995); Scribner (Tobach et al, 1997) and Walkerdine (1988). Vygotsky and Leont'ev both stress the importance of the social role in human development and learning. However, while Vygotsky tended to emphasise immediate social relationships, as discussed above, Leont'ev's focus was on the broader societal context. This will be elaborated in section 3.3.2.4.

3.2.2.4 Mediation Of Thought

A major goal of Vygotsky was to develop a psychology able to account for the nature of human consciousness. Influenced by his knowledge and interest in art and literature, Vygotsky extended the Marxist concept of physical tools as mediating devices, to mental tools. To Vygotsky (1981b, p. 140):

> The most essential feature distinguishing the psychological tool from the technical tool is that it directs the mind and behaviour whereas the technical tool, which is also inserted as an intermediate link between human activity and the external object, is directed toward producing one or another set of changes in the object itself.

That is, psychological tools are aimed at mastery or regulation of oneself or others, rather than controlling the physical environment. In a dialectic way, these human transformations lead to the need for further mental tools which again give rise to new ways of conceptualising and acting in the world. Mental tools, for example, scientific theories, are cultural. They are invented and passed on to others through social processes and socially structured practices. According to Wertsch et al (1995, p. 21) they:

> provide the link or bridge between the concrete actions carried out by individuals and groups, on the one hand, and cultural, institutional, and historical settings, on the other.

In Vygotsky's writing, the main mediators are words, symbols and other signs (Kozulin, 1986, Zinchenko, 1995). In this context, a sign has:

> a definite meaning that has evolved in the history of a culture (Davydov & Radzikhovskii, 1985, p. 54).

A sign can serve as a system of reference, such as "notched sticks and knots", or writing (Vygotsky, 1978, p. 39). It can also make possible new, higher levels of thought and analysis, as do, for example, algebraic systems. Vygotsky was particularly interested in the role of the sign, especially the word, in the development of higher mental functions. To Vygotsky (1962, p. 56):

> All the higher psychic functions are mediated processes, and signs are the basic means used to master and direct them. The mediating sign is incorporated in their structure as an indispensable, indeed the central, part of the total process. In concept formation, that sign is the *word*, which at first plays the role of means in forming a concept and later becomes its symbol.

So to Vygotsky, signs enable higher mental processes, such as concept formation, to develop and they also signify meanings. Vygotsky and his colleagues and students, including Luria and Leont'ev, carried out many empirical studies on children and on rural peoples in order to understand how the processes of internalisation of speech and other semiotic systems allowed thinking to develop. Luria & Yudovich (1959, p. 13) posit that:

> The word, handing on the experience of generations as this is incorporated in language, locks a complex system of connections in the child's cortex and becomes a tremendous tool, introducing forms of analysis and synthesis into the child's perception which he would be unable to develop by himself.

That is, the internalisation of word meaning, which is socially developed, provides the structure for the development of cognition.

Mental tools, in Vygotsky's thinking, extend the mind. They allow humans to do more than react to the environment as animals must — they enable us to change our environments. This implies that human behaviour is purposeful. We use tools, and signs, especially language (both as a symbolic system and as speech) in order to carry out our plans, to cooperate with others and to regulate our own cognitive processes, such as focusing our attention or remembering, in considered, deliberate ways. In Vygotsky's thesis, cognitive functioning is shaped by the sociocultural setting. Mediation by means of cultural tools serves as the mechanism for this shaping.

3.3 DEVELOPMENT AND PRINCIPLES OF ACTIVITY THEORY

3.3.1 Historical Background

Many of Vygotsky's conceptions, including those described above, greatly influenced and were further developed by his contemporaries, Luria, Leont'ev and other psychologists of the former Soviet Union. It is customary for Western authors to refer to Vygotsky, Luria and Leont'ev as a "troika" (Blanck, 1990, p. 39) developing their theories in unity. Van der Veer & Valsiner (1991) dispel this unity as a myth, contending that different attitudes and thinking, as well as strong personal disagreements, marked the relationships among the three. Indeed Leont'ev did not co-author research publications with Vygotsky, although he did considerable empirical work in support of Vygotsky's theories (Van der Veer & Valsiner, 1991).

Leont'ev's work on psychological functions began under Chelpanov at the Moscow Institute of Experimental Psychology, formerly the Psychological Institute. In 1923 Chelpanov was expelled from the Institute, which he had himself established in 1912, in favour of his one time student and strident critic, Kornilov, a reactologist. Leont'ev, under the guidance of Luria and Vygotsky, worked at the Institute under Kornilov, who was rushing to re-organise it along the lines of the new Marxist psychology (Van der Veer & Valsiner, 1991). Luria is cited (in Van der Veer & Valsiner, 1991, p. 127) as describing, with tongue in cheek, his early days under Kornilov as follows:

> Our Institute was supposed to reform the whole psychological science by abandoning Chelpanov's idealistic theory and creating a new materialist one. ... Meanwhile the reform of psychology was proceeding in two forms: first, by way of renaming things, and second, by way of moving furniture.

In the early 1930's Leont'ev moved from Moscow to Khar'kov where he created his own school of psychology. His approach came to be known as the "activity approach in psychology" or the "psychological theory of activity" (Zinchenko, 1995, p. 38). For Vygotsky and others of the cultural historical school, the focus of research was the development of mind and consciousness and how these are mediated by psychological instruments, especially words and other signs (Wertsch, 1985; Zinchenko, 1995). To Leont'ev, in accordance with Marxism, the unit of psychological analysis is activity, and physical tools and concrete objects mediate the connection of humans and the natural world (Leont'ev, 1978, 1981).

Activity theory is, however, grounded in and uses Vygotsky's concepts. For example Leont'ev re-interpreted Vygotsky's analysis of speech in terms of speech activity (Wertsch et al, 1995). Wertsch et al (1995, p. 12) argue that the "action orientation" of Vygotsky has been obscured by his distinction between speech and language. To Vygotsky, as to his Russian colleague Bakhtin, a linguistic philosopher, speech is a process, language is a semiotic means. That is, speech is a form of action. Language, while "it has the power to shape speaking and thinking" is not an action in Vygotsky's terms (Wertsch et al, 1995, p. 12). There is a difference between speech, as utterances, and language, as a system of communication. This difference is in the emphasis on different aspects — "the vocal and the semantic" which Vygotsky saw as related, but with different patterns of development (Vygotsky, 1962, p. 126). Vygotsky tended to focus on speech as opposed to language. However, he also paid attention to the symbolic properties of the mediator as central to the action of meaning making. Leont'ev, however, stressed the external active form of speech. While Vygotsky regarded word meaning as the appropriate unit of analysis, Leont'ev based his analysis on activity. In both cases these units are cultural. The title of Vygotsky's last volume *Thinking and Speech* (although mistranslated as *Thought and Language* in earlier editions) highlights the "action dynamic" in Vygotsky's thesis (Wertsch et al, 1995, p. 12). Indeed, the important part played by Vygotsky in the creation and development of the activity paradigm itself was acknowledged by Leont'ev in his obituary of Vygotsky (Zinchenko, 1995).

Leont'ev's interpretation of Vygotsky's theories must be seen in the light of his attempts to rehabilitate Vygotsky's work (Cobb, Perlwitz & Underwood, 1996) after the latter's work was banned by the Russian authorities soon after his death in 1934. In the repressive climate of the former Soviet Union in the pre-Glasnost era, researchers were forced to demonstrate their loyalty to the prevailing ideology (Van der Veer & Valsiner, 1991). Vygotsky came under increasing attack and his refusal to adhere to strictly Marxist principles regarding the primacy of material production was cited by Petr Zinchenko and other contemporaries of Vygotsky as a fundamental error (Kozulin, 1990).

Vladimir Zinchenko, the son of Petr Zinchenko, affirms that Vygotsky and any who supported him were in danger of losing their freedom, if not their lives (V. P. Zinchenko, 1995). He notes that cultural-historical psychology emerged during the "dismemberment" of Russian culture, en route to communism, while the background to activity theory was the "unprecedented" enslavement of the country's peasants (ibid, p. 52). Hence, the very emergence of these theories, was, in V. P. Zinchenko's opinion, miraculous. Bodrova and Leong (1996) applaud the courage of those like Leont'ev who continued to expand and elaborate on Vygotsky's theories after the latter's death, despite the risks. (Bodrova studied with Leont'ev, Elkonin, Galperin and other colleagues and students of Vygotsky). In their opinion, such people were then able to revive Vygotsky's ideas in the late fifties after the bans had been lifted. Other commentators paint a less rosy picture of the actions of Leont'ev and Luria, indicating that they did not always stand up for academic freedoms (Van der Veer & Valsiner, 1991). Clearly Russian society at the time was a maelstrom and simplistic judgements cannot be made about those trying to steer their courses through the storms.

In V. P. Zinchenko's (1995) view, Vygotsky's students and colleagues, such as Leont'ev, did not simply camouflage their earlier views after Vygotsky's death but worked in a new direction. Leont'ev's line of research was distinct from Vygotsky's and:

> today we are dealing with two scientific paradigms: cultural-historical psychology and the psychological theory of activity (V. P. Zinchenko, 1995, p. 40).

These two strands of research can be seen as mutually amplifying and enriching each other.

3.3.2 Principles Of Activity Theory

Davydov (1993, p. 50) an "avowed adherent" of activity theory, and arguably one of its most well known Russian advocates in the contemporary Western world, explains that Marx took activity as a key concept to explain the development of economic life. This concept of activity was worked out in the context of German classical philosophy. Philosophers, such as Kant and Hegel formulated the groundwork for the concept of activity, its structure and its formation in the sociocultural realm. Marx emphasised the manufacture of artefacts as satisfying the basic needs of humans (For example, Marx, 1987). In his view, production, or labour, is the means by which man changes nature and at the same time, his own nature. This production depends on the use of tools. Mental abilities, too, arise in the process of material production and the inter-personal relationships surrounding it. According to Marx, human activity involving labour is the foundation for collective and individual consciousness. That is, activity is the basis of “the personal and social identity of the individual” (Davydov, 1993, p. 51).

In Russia, after the October 1917 Revolution, the concept of activity was developed in terms of disciplines such as philosophy and psychology. There were many different versions of activity theory of which Leont’ev’s became the most well known (Van der Veer & Valsiner, 1991). Indeed, Gilgen & Gilgen (1996, p. 29) comment that in scholarly publications written in English as well as in Russian, Leont’ev’s account of Soviet psychology “predominated from the 1950’s to the end of the Soviet regime in 1991”. In part this is due to the prominent positions held by Leont’ev in Russia, which included Chairman of the Department of Psychology, Moscow State University (see Cole & Maltzman’s introduction to Leont’ev, 1969).

Lektorsky, a Russian philosopher, is cited by Cobb et al (1996) as an expert in activity theory. Lektorsky (1984, p. 258) explains cognition in terms of Marxist philosophy as follows:

> Marxist philosophy asserts that cognition is founded on practical activity and that the latter must be understood in its specifically human characteristics, to wit, as collective or joint activity, in which the individual enters upon definite relations with other persons, as mediated activity in which man places between himself and an external naturally emerging object other man made objects functioning as the implements of activity: and finally, as a historically developing activity carrying in itself its own history.

In this, somewhat dense, sentence are the basic tenets of activity theory. The first of these is that activity is the explanatory principle in psychological theory. Secondly, Lektorsky equates cognition as socialisation, as Vygotsky (1978) claimed, with cognition as the "interiorization" of external actions, in Leont'ev's terms (Leont'ev, 1978, p. 61) by describing all practical activity or labour as being collective. That is, all activity is of a social nature. Thirdly, activity is mediated by cultural tools which shape the individual's functioning. Finally there is the idea of the mutual formation of mind and the social world in history. This last idea is expressed cogently by Varela et al (1991) who propose that mind and the world co-emerge by structural coupling, much as the colours of flowers and the vision of bees co-evolve.

Davydov (1993) makes the point that the term "activity" does not have the same frame of reference everywhere, in research in the social sciences. In English, the word covers all kinds of overt and covert actions. In Leont'ev's activity theory the term:

> refers exclusively to events in which actions are judged by their intention to change reality (Davydov, 1993, p. 51).

That is, activity is differentiated from other human actions by means of being goal driven. Davydov (1993, p. 50) defines activity in this framework in the following way:

> Activity is a specific species of human societal existence which aims at a goal directed change of physical and social reality.

So, individual activity is embedded in and transforms the social and cultural life of the community. At the level of the individual, activity brings together a goal, the means for realising this goal, the actual process of transformation and its effect or outcome. Each of these is organised within a societal setting. The goal of activity emerges first as a schematic model of the desired outcome of the actions. That is, practical actions start with mental plans. This has the effect of creating opportunities — of rising above the limits as they exist and so increasing the options available.

The “system” (Leont’ev, 1981, p. 47) of collective activity which relates people to each other, their cultural history and their realm of action is called an “activity system” by Engeström (1993, p. 66). Taken as a unit of analysis, it confers meaning on seemingly random and individual behaviour. The activity system of people acting in their historically formed and social world is in a process of change and contradiction. The dialectics of the fusion of the subject and the external world (person and context) are explained by Lektorsky (1984, p. 127) by quoting Lenin as follows:

> The reflection of nature in man’s thought must be understood not ‘lifelessly’, not ‘abstractly,’ *not devoid of movement, not without contradictions,* but in the eternal *process* of movement, the arising of contradictions and their solution.

It is these perturbations which lead to development of the system including the development of its participants.

The following sections clarify the main principles underlying activity theory.

3.3.2.1 Activity Is The Explanatory Principle Of Psychology

Leont’ev, (1981, p. 53) stressed that consciousness is “generated” by and inseparable from external activity. In his view, based on Marxism, activity must have associated external behaviour and mental images are direct products of contact with the world of objects. In this thinking, Leont’ev was influenced by others including, importantly, Rubinshtein and Vygotsky (see section 2.4.3) but his thinking differed from each of theirs, as will be clarified below.

Rubinshtein, like Leont’ev, proposed that consciousness and behaviour represent a unity (Leont’ev, 1981). Rubinshtein defined individual consciousness as:

> the person’s ability to regulate not only movements, acts and operations taking place at a particular time but also the entire life span (Abulkhanova-Slavskaya & Brushlinsky, 1996, p. 198).

Rubinshtein’s ideas accord with those of Piaget, in that he focused on the roles of individuals’ independent explorations and interactions with the objective world as the sources of their reflections of it (Gilgen & Gilgen, 1996). That is, Rubinshtein’s position puts the (acting) subject at the centre of psychology.

Vygotsky put interaction and communication among people at the centre of individual psychological development. As discussed earlier in this chapter (section 3.2.2.3) Vygotsky (1978) explained the development of higher mental faculties in terms of historically developed social interactions. In his theory, it is these internalised social interactions and communications that are the basis of cognitive development.

Diverging from both Vygotsky and Rubinshtein, Leont'ev proposed that activity is at the centre of a person's connection with others and the external world. Activity includes interaction with others and it also includes reflection, but Leont'ev's emphasis is on external actions (Leont'ev, 1981). That is, according to Leont'ev (1981) individual psychological experiences are expressed through external, practical activity. Activity connects individuals to their communities and connects material objects to the psychological faculties that illuminate these objects.

This leads to the question of how objects are connected with the mind. Bakhurst, an American interpreter of activity theory, solves the problem by referring to the meaning of objects acquired by them in social practice (Bakhurst, 1988, in Cobb et al, 1996). That is the "ideal" (in the sense of imagery, of being in the mind) existence of objects is completely different from its physical nature — the stuff of which it is made. It is an artefact endowed with social significance. To illustrate this, Bakhurst describes a pen as a form which objectifies a social purpose. The meanings that a community give to an object transform it into a cultural artefact which has ideal properties. These properties become accessible to our minds when we participate in the social practices for which the object was developed. Hence, writing with a pen gives it its "reality". This idea of objects as mediators of sociohistorical experience is also applicable to symbols, referred to by Lektorsky (1984) as symbols-in-practice, rather than just symbols. For example, Lektorsky (1984, p. 211) argues that when we read text and try to understand it, we focus on the content expressed with the help of letters, but ignore any characteristics of the letters that are "indifferent" to meaning making, such as their individual shapes.

3.3.2.2 Activity Is Purposive

According to Leont'ev (1981, p. 59):

> There can be no activity without a motive. 'Unmotivated' activity is not activity devoid of a motive: it is activity with a motive that is subjectively and objectively concealed.

Hence to Leont'ev, some motive, whether conscious or unconscious, always stands behind activity. Motives, needs and desires are translated into action by means of goals (see section 2.4.4.2).

Motivation and goal formulation are inherently social. They connect psychological phenomena to the social world. Leont'ev (1981, p. 50) proposes that when a desire meets the object of desire, it is filled "with content from the surrounding world". That is, individual actions are embedded in larger systems of activity called "socially patterned systems of activities" by Scribner (Tobach et al, 1997, p. 270) and are directed towards satisfying motives. These systems of activity are socially patterned in three ways: the goals they satisfy are socially generated, they are carried out through social means and they are connected to a system of collective activity which has developed over human history.

The idea of a goal follows from the Marxist concept of labour. This notion is interpreted by Davydov (1990, p. 233) as follows:

> At the end of the labor process a result is obtained which existed in the person's conception even at the start of the process—that is, ideally.

That is, according to the theories of Marx and Engels, the human ability to formulate and carry out conscious goals provides the cognitive framework for humans to enter into production. In line with the Marxist paradigm, Leont'ev's theory postulates that human motives are determined by the division of labour in society, and that within this framework, specific, concrete actions are related to practical goals (Kozulin, 1990).

In Leont'ev's theory, the idea of individual potential emerges from his postulate that actions are consciously directed at a goal (Leont'ev, 1978). The intention of cognition, in the sense of directedness, implies an awareness of what possibilities for action there are, and an understanding of how the context constrains the actions or enables the fulfilment of these possibilities.

Historically, goal formation was one of the major research topics in psychology in the former Soviet Union (Wertsch, 1981). Current research in the West (for example in Australia: Lawrence & Volet, 1991; Volet, 1997; Volet & Lawrence; 1989) has also provided empirical support for the importance of personal goals as directing the learning of university students. The research highlights the importance of goals in the self regulation of students' activities, the complexity of the dynamics of goal formation and development in academic settings, and the ways goals are responsive or resistant to the environment. In contrast to Leont'ev's ideas, however, this research gives an account of students' goals that:

> precludes any easy invocation of goals as causes of particular sets of actions (Lawrence and Volet, 1991, p. 152).

That is, goal directedness is neither transparent nor unequivocal.

3.3.2.3 Activity Is Mediated

Activity can be thought of as having a tripartite structure consisting of the individual, the environment and the tool, which, as a cultural mediator, is both the agent and reflector of change. Leont'ev (1981) explains that the tool mediates activity and in this way connects humans with concrete objects and also with other people. He specifies that it is not the cultural tool, as an artefact, but the use of that tool that mediates or shapes mental processes. That is:

> the formation of uniquely human functional systems takes place as a result of mastering tools (means) and operations (Leont'ev, 1981, p. 67).

Moreover, Leont'ev contended that such mediators do not simply facilitate human thinking and agency. As the social structure and tools of production change, so does human thinking (Leont'ev, 1981). This relates to Vygotsky's idea that as technical tools alter the operations of labour, so psychological tools transform "the entire flow and structure of mental functions" (Vygotsky, 1981b, p. 137).

This premise is most pertinent to our society with its rapid technological transformations. For example, the ways we use our memories and other mental abilities have changed dramatically with "extra-cerebral" tools (Leont'ev, 1981, p. 64) like the Internet, and even calculators. These have taken over the function of storing vast amounts of information and of processing information by means of complex algorithms, thus allowing for increased expertise and more complex mental actions, such as problem solving.

3.3.2.4 Activity Theory Emphasises The Interdependence And Interaction Of Sociocultural And Cognitive Processes

The view that cognitive abilities of the child or novice emerge from interaction with adults or experts was developed by Vygotsky (1962) who proposed that cognitive processes are carried out interpsychologically then intrapsychologically, or from the social to the individual plane. That is, they are first carried out initially with help from an adult or expert, then transformed to a self directed carrying out of the task, via the zone of proximal development (Vygotsky, 1978). Speech is the major mediational means which directs this process. In Leont'ev's modification of this theme, activity is the major source of cognitive development. Psychological functions, too, such as thinking, are actions in Leont'ev's terms.

Leont'ev proposed that cognition can exist only in the presence of and embedded in social consciousness — what Leont'ev, echoing Vygotsky, called "co-knowing" (Leont'ev, 1978, p. 60). It lives only in an environment of socially constituted meanings and is developed by the appropriate use of cultural tools. Leont'ev (1981) proposed that inner mental processes originate from external activity which serves a practical, socially developed purpose. That is, thought is "not in the head", in a private world of consciousness, but in the performance of social activities (Bakhurst, 1988). External practical activity is internalised, that is, changed into processes that take place at the level of consciousness. Leont'ev (1981, p. 57) expressed this as "... life underlies consciousness". During the transition these external processes become generalised, verbalised, abbreviated and become the means for development beyond the bounds of only external activity. Leont'ev (1981, p. 55) quotes Piaget as formulating that this conversion "leads from the sensory-motor plane to thought".

A specific account of this essentially social process of transformation is provided by Davydov & Andronov (1981). They call it a "test tube" example of the emergence of mathematical thinking (Davydov & Andronov, 1981, p. 25). In their study of young children working on addition problems, the mental act of addition initially takes place as an overt action, a sweeping hand movement as the number is pronounced. The gesture, in turn, becoming a symbol for the number, is reduced, and, together with speech, becomes the means for organising the child's mathematical thinking during the problem solving.

Davydov (1990, p. 311) explains that through instruction:

> every individual *appropriates to himself,* converts into forms of *his own* activity, the means and methods of thought that have been created by society at that historical epoch.

This idea stresses the sociohistorical roots of cognition. It also emphasises the engagement of the individual. The term "appropriate", like the term "construct" (Cobb, 1989) highlights the active role of the learner. This is particularly relevant to students learning Statistics. Statistics is an artefact of our technological era with a history of development in society and it is perceived differently by each individual as he or she "appropriates" it, in Davydov's (1990) term.

Cobb et al (1996) sums up the different senses in which Vygotsky and Leont'ev view an individual's actions as being social as follows.

- Vygotsky views personal actions as involving direct interactions with others.
- Activity theorists view individual actions in terms of the broader sociocultural system.

The latter view is a stronger, more encompassing account of social. Minick (1989, quoted in Cobb et al, 1996, p. 26) points out, as a key element of the activity framework, that:

> psychological characteristics are conceptualized not as characteristics of the individual but as characteristics of the individual-in-(social)-action.

This stronger meaning of social has been applied in many studies of situated mathematical activity such as investigations into the delivery of milk crates or into supermarket shopping (in Rogoff & Lave, 1984). In these studies, and in my own investigation, individuals participate in social activity which may, but does not always, include face to face interaction.

Lektorsky (1984) argues that there is a continuity between Vygotsky's notion of social activity as the determinant of psychological development and Leont'ev's focus on mental abilities being derived from labour or practical activity. According to Lektorsky, a person's cognition is shaped by interacting with others who teach him to use man-made things. Lektorsky combines Vygotsky's and Leont'ev's proposed mechanisms for the development of the psyche, by explaining that an individual's consciousness is founded in the direct links between practical activity, cognition and "the living communicative connections with other persons" (Lektorsky, 1984, p. 259).

3.4 ILLUSTRATIONS OF THE FEATURES OF ACTIVITY THEORY: EXAMPLES FROM MY PRACTICE

So far, in this chapter and in the previous chapter, I have outlined a model for understanding learning suggested by the theory of activity. In summary, in explaining cognition, the emphases of activity theory are on its connected elements and mediated structure, how it functions by means of goal directed actions and on its cultural and historical development.

Engeström (1993) points out that activity theory does not offer ready made techniques and procedures. Its conceptual tools and methodological principles:

> have to be concretized according to the specific nature of the object under scrutiny (Engeström 1993, p. 97).

In this section I present some of the elements of the theoretical framework which are of interest to me in defining the activity of learning Statistics. I shall attempt to illustrate these factors with examples drawn from my teaching practice. The section concludes with some implications of the activity theory approach for understanding learning and teaching.

3.4.1 Dialectic Of Student, Activity And Setting

My perspective stresses that it is not fixed or pre-ordained features of the setting or of the individual learner that determine the learning. The student as a learner and the context of her learning are mutually constituted in social action. I agree with Ratner's (1996, p. 420) interpretation that:

> social activity not only determines the content of psychological phenomena. Activity also conditions the particular fields of life in which a psychological phenomenon is employed.

Ratner (1966) points out that culture means that there is a specific, practical system operating. This determines the distribution of power, privileges and resources. It establishes the ways in which tasks are separated from one another, for example, school learning and vocational training. It influences how people act and relate to each other in different social practices, such as during work and at home. Ratner (1996) argues that, although culture is commonly recognised as the sharing of conceptual meanings and understandings, it also includes these practical aspects. These must be recognised for the important ways in which they affect people's psychological processes. Hofstede (1991) describes different dimensions of culture, such as gender roles, individualism versus collectivism and distribution of power, that are important in the organisation of people's behaviour and thinking. These will be discussed in Chapter Nine (section 9.2.3) with reference to my findings.

In Australia, higher education is undergoing massive changes, in part due to political and economic policies. These policies are transforming the ways in which educational processes are framed. For example, the ways that educators examine students, their priorities with respect to teaching and research, the efforts they make to reform the curriculum, the demands on their time and the resources available to them reflect the political and economic environment. These policies even transform perceptions of the past. For example, current “cut backs” in departmental budgets instantaneously transform the past into a golden era — a supposed time of plenty from which things have been cut back.

The educational context shapes the ways in which students learn. In turn, students’ actions change the teaching situation which surrounds them, including the actions of educators. For example, if an educator teaches the same topic for two or more years, the teaching strategies and methods of communication which “worked” one year may be dramatically changed the following year. Such changes may reflect the social environment produced by the members of each new class.

The activity theory approach to education asserts that knowledge, and ways of gaining knowledge, have a social ontogeny. One implication of this is that students’ previous experiences can be ameliorated. This fits with my own experience of teaching situations. For example, it was the case for Jane, an older student whom I helped with Statistics at the Mathematics Learning Centre. She felt that she had not succeeded with mathematical subjects before coming to university. She did not believe herself to be capable of doing so. I interviewed her after she had achieved very good results in Statistics and she described her feelings as follows:

> When I’ve got my (Statistics) notes and my calculator I feel invincible. ... I found that I actually knew more than some other people. Instead of being the one who knew the least. And that gave me an enormous sense of power — or a bit of power anyway — that I could actually know more than somebody else.

As in Jane's case, not only do students' perspectives and insights into a particular field of knowledge change, but also their very self concepts. Slotnick, Pelton, Fuller & Tabor (1993, p. 18) propose that in answering a student's questions, an instructor is not only helping that person advance her skills in reasoning and logic and providing a role model for dealing with complex issues, but is also "validating" that person, that is, confirming her identity.

Changes in students have been empirically demonstrated in the case of mature students who attend university (Belenkey, Clinchy, Goldberger & Tarule, 1986; Volet & Lawrence, 1989). These transformations are related to their experiences and to their goals, which unfold and are structured by the social and cultural meaning of the events (Volet & Chalmers, 1992). Further, this social meaning is embedded in specific, practical situations of activity. Jane's activity took place in a particular university within the wider Australian culture, surrounded by the customs, norms and gender roles pertaining both to the institution and to our society. Each of these arenas — her immediate social environment, the institutional setting and the wider Australian society — are contextual orbits within which Jane's activity was organised. By the word "orbits" I am emphasising that the structures operating on Jane were undergoing changes themselves, while seeming to be static — as the earth, surrounding us, appears static although we know it is moving. It is these contexts that influenced the way Jane thought about herself and structured the tasks in which she was engaged. They determined which of her actions were rewarded and how they were rewarded and what demands were placed on her.

3.4.2 Vignettes From My Practice

The theoretical approach outlined in section 3.3 offers ways of interpreting students' actions. In order to clarify the ideas I have introduced in this chapter, I summarise my interpretation of key features of activity theory by means of examples. The following excerpts are from transcribed interviews with students whom I assisted with various statistics courses (published in Gordon, 1994 and 1995b). These are snapshots, taken from different angles, of an activity system of students acting in their institutional worlds. They capture images of ongoing and dynamic processes.

- **Activities are distinguished by their energising motives**

Brenda, first year statistics student, age 23, said this:

> I'd like to understand what I'm doing. I don't just want to pass statistics, scrape through. I want to work. My whole attitude's totally different from when I was at school. I didn't care when I was at school. I became a Christian a couple of years ago. And so my whole attitude changed and now I guess I've got a goal and now I've got a reason for being alive basically.
>
> I never did well at anything at school and last year the course I did, out of 160 people I came first. That's amazing. That for me is amazing.

Brenda's quote illustrates the essence of activity as encompassing her total perspective on life. Her actions in the educational setting were guided and directed by her underlying raison d' être — in this case spiritual inspiration, and this resulted in a very favourable outcome.

- **Activity theory emphasises the interdependence and interaction of learning processes and cultural background**

The following excerpt is from an interview with a first year statistics student, Huong, who recently entered Australia. Huong expressed a mismatch between her schooling in Vietnam and the ways she was expected to learn statistics in Australia.

> There is a big difference between the math I did at high school and this statistics course. Everything is new for me. From the beginning of this year I learn how to use a calculator and how to work with the terms in math, how mathematics terms mean in English. But it is hard to learn to solve problems because in my country the way to learn is just to memorise by heart. We had no chance to practice to think for ourself. Just to memorise what the teacher said to us.

From the activity theory point of view, this excerpt is an invitation to explore the roles of memorisation in different cultures. For example, Biggs (1993) cites studies investigating how Asian and Australian students use memorising. These show, that in our culture, memorising with the intention of reproducing material may not lead to understanding, and is then inappropriate to the task of learning. For Chinese students in Hong Kong, it is more likely that memorising leads to understanding — the way that material is internalised is part of a deep approach to learning. Further exploration on the relation between memorisation and understanding for Chinese learners is provided by Marton et al (1997).

- **Actions are socially formulated**

Eve: second year Psychology student describing her mainstream Statistics tutorials:

> Its much more like you imagine university maths to be ... nobody will ask questions. It doesn't seem to be the done thing.

Hence Eve's actions were prescribed by unwritten codes of social conduct in tutorials, as she perceived them.

- **Activity involves self regulation**

student repeating Psychology II course:

> I can't use any of my own knowledge for Statistics. I can't use any of my analytical or philosophical skills or just like experiences in life — it's rote learning and its just so different.

This quote expresses the mutual structuring of this student's conceptions of learning Statistics and her regulation of her actions to learn it.

3.4.3 Implications For The Analysis Of Learning

The vignettes above illustrate some aspects of my perspective drawing on activity theory. This perspective has implications for the ways in which we view the learning process. I will outline some of these below. These implications are not, of course, unique to this paradigm. Indeed, viable research and teaching may follow from more than one paradigm.

i) The activity framework implies a commitment to investigating the learning process as a dynamic process and one in which society and the individual interact and evolve rather than the student as a closed system or passive receiver of ready made information.

ii) The theory presents different levels at which learning can be analysed: the global level of the context of the learning, the level of the goal directed actions, that is, how the task was carried out and the level of the operations, which, according to Leont'ev, depend on the means by which an action is carried out (Leont'ev, 1981).

iii) It emphasises the social dimension of learning: certain behaviour is acceptable in an arena of action, such as a tutorial session, other behaviour is not.

iv) It sensitises us to cultural effects. This is particularly pertinent for studying the learning of statistics as our current Western consumer society is immersed in statistics yet not all students are familiar or comfortable with this.

v) It takes account of goals. The degree to which the goals set by the educator fit with those of the students will affect their involvement in the tasks set for them.

vi) A Vygotskian perspective recognises the importance of language and symbols. Statistics is a branch of mathematics which has a large verbal component. The language used in statistics, described by one European born student as "English acrobatics" is often the very aspect that confuses students.

vii) A further strength of the Vygotskian approach is its emphasis on underlying metacognitive skills, such as self regulation (Bodrova and Leong, 1966). Empirical research shows that these are important for the development of appropriate learning strategies (Rojas-Drummond, Hernández, Vélez & Villagrán, 1998).

viii) In sharp contrast to psychological theories which view cognitive processes as separate from the emotional domain, activity theory emphasises the inseparability of students' feelings from their thinking. These cannot be considered as discrete, additive components. Leont'ev concurred with Vygotsky that motivation and the affective volitional sphere were the "hidden" plane of thinking (Leont'ev, 1981, p. 57). According to Vygotsky, the separation of intellect and affect as subjects of study:

> makes the thought process appear as an autonomous flow of 'thoughts thinking themselves,' segregated from the fullness of life, from the personal needs and interests, the inclinations and impulses, of the thinker (Vygotsky, 1962, p. 8)

Rather than needs, feelings and emotions being treated as residing within the individual, influenced by the environment — a precondition of action, an activity theory approach regards these as unified aspects of human functioning.

3.5 ISSUES CONCERNING CONTEMPORARY INTERPRETATIONS OF ACTIVITY THEORY

3.5.1 Problems In The Theoretical Assertions Of Activity Theory

A number of unsolved problems and issues pertaining to activity theory have been highlighted in recent research. These include the meaning of the construct "activity"; issues concerning learning by "internalization" (Leont'ev, 1981, p. 55); the nature of knowledge and of reality and methodological problems concerning activity as a unit of analysis.

Davydov (1991, 1993) presents a number of problems pertaining to "activity", itself. Firstly, despite his own extensive work clarifying it, he regards the basic meaning of activity to be inadequately conceptualised. Activity, in his opinion, is insufficiently differentiated from other human actions, despite the emphasis on its goal orientation. Davydov (1993) argues that each type of activity, such as art, politics or labour, must be understood in terms of its own cultural historical formation. For example, what types of instructional activity (school learning) were privileged in specific historical periods? He also holds that each type of activity (as changing reality) is embedded in processes of interpersonal relationships. These, too, must be explicated in order to understand the activity. In my project the activity of learning Statistics is interpreted in an institutional setting, which is culturally and historically formed and organised. It relates also to the interactions among students and academics.

One of the most widely criticised aspects of activity theory concerns the process of internalisation (Bauersfeld, 1992). This is a notion of Vygotsky (1962, 1978) which is also central to Leont'ev's theory (Leont'ev, 1981). Two major concerns are highlighted by Bauersfeld (1992). One pertains to how individual activity is formed on the basis of collective activity. The second aspect relates to the idea that what is internalised is ready made and singular.

The first issue was raised by Davydov (1991) who criticised Leont'ev for pointing out the similarities, but not the differences in structure, between collective activity and individual activity. To Davydov it is not clear how individual functioning, such as remembering, would be derived from a differently structured collective activity. One explanation that I offer in the case of remembering is that collective memories are individually accessed as metaphors. For example, children are told fairy stories about dangers which have their roots in "tribal" memories. The chances of an Australian child encountering a wolf (or even a dingo) on route to her grandmother are remote for the vast majority. However, this "tribal" memory serves a useful purpose in the child's current behaviour, assisting her to cope with life by warning her of its dangers and also enabling her to access and express her emotions. Also, individual memories can be jogged and even amended by means of external aids such as photographs or the recollections of others.

The second concern relates to the idea that what is internalised is ready made and singular. This seems to suggest that there is a historically formed, objective reality "out there", which can be used to lead development. This aspect leads to problems explaining creativity and also suggests that knowledge is ready made. To Rogoff (1995, p. 151) the idea of internalisation suggests that:

> something static is taken across a boundary from the external to the internal.

Rogoff (1995) like Davydov (1990) uses the term "appropriate" rather than "internalise" to emphasise the person's participation in an activity. Rogoff (1995, p. 152) also proposes that "participatory appropriation" is a "process of transformation", whereby

> the boundary itself is questioned, since a person who is participating in an activity is part of that activity.

Rogoff (1995) comments that Vygotsky's notion of internalisation may be similar to her idea of appropriation in that transformation is inherent to his notion. To Leont'ev, too, internalisation is a dynamic, active process (see section 2.4.4.1). However, Rogoff's term "participatory appropriation", in which the person and the social world are not separate, contrasts with the "internalisation" of an event or knowledge which is external to the individual.

The idea of historically formed, crystallised (Leont'ev, 1978) external knowledge can lead to a positivist and reductionist view of mathematics. Teaching mathematics from this perspective would mean guiding students to the "truth", using direct instruction, powerful mediational means and explication of reflective strategies (Bauersfeld, 1992, p. 21). In contrast, teaching mathematics is problematic from the constructivist perspective. A teacher cannot transmit knowledge or expose information (ibid). Burton (1995, p. 277) emphasises the:

> interaction between individuals, society and knowledge out of which mathematical meaning is created.

This is a non-positivist position which fits with the metaphors of co-emergence of person and knowledge (Varela et al, 1991) and of the interactionist perspective (for example, Bauersfeld, 1994). My understanding agrees with the latter positions. Rather than mathematical knowledge as non-negotiable and absolute "truth", it is constituted in the relationships among what is learned, those who learn or use it and the society within which it develops.

On a methodological level, Leont'ev has been criticised as viewing activity both as a unit of life which can be analysed by means of different levels (activity, actions, operations) and a means of investigating life itself (Kozulin, 1986). Kozulin (1986) considers this to be a consequence of the rejection by Leont'ev and his followers of Vygotsky's notions concerning the role of semiotic systems, or cultural signs in general. In his effort to adhere to Marxist principles, Leont'ev saw activity as providing not only the subject matter but also the methodology or explanatory principle for psychology. To Vygotsky, in contrast, higher mental functioning cannot be explained without reference to semiotic mediation.

To avoid this circularity of explaining activity by means of activity, I will treat students' reported activities in learning Statistics as the object of my investigation. Actions and operations will be regarded as components of their activity. Moreover, in my investigation I will confine my focus to what is accessible through students' awareness. Leont'ev insists on all actions as goal directed. However, we do not always articulate, and are not necessarily even aware of, the motives for our actions. Activities that comprise of purposeful actions are, however, accessible to research through the awareness of the participants or actors.

3.5.2 Taking Activity Theory Into The Future

The ideas of Vygotsky, Leont'ev and other theorists of the former Soviet Union have provided and continue to provide fruitful areas of research both in the East and in the West. Lektorsky (1993) comments that in the birthplace of activity theory, there is much criticism, in intellectual circles, of activity theory. Firstly, there is the understandable repudiation by these people of totalitarianism and philosophies based upon it. As Davydov (1993, p. 51) concurs, activity theory:

> came to be fiercely criticised because it was connected with the idea of technological progress in which the ethical dimension is put between brackets.

Secondly, and linked to the previous critique, it is argued that the emphasis in activity theory on objectivity, as opposed to subjectivity, has led to the suppression of ideas about the creativity of individuals. That is, activity theory is criticised as representing humans not as creative beings but as interiorisers (Leont'ev, 1981) of ready made standards of behaviour and cognition.

While concurring with these criticisms, Lektorsky (1993) argues that Vygotsky's and Leont'ev's ideas should not all be rejected with Marxism. He also advocates that activity theory should be developed in new and fruitful ways. He argues that to understand activity we would do well to return to the ideas of Vygotsky who stressed not only interiorisation but exteriorisation — the ways people create new standards and rules. In this view, human beings are essentially creative beings who "determine themselves through objects that they create" (Lektorsky, 1993, p. 49).

Davydov (1993, p. 50) argues that the concept of activity refers primarily to the:

> openness and universality of human actions. Consequently, 'activity' should be interpreted as a form of creativity which is determined by the actual cultural-historical context.

To Davydov (1993, p. 52) totalitarianism intruded on a concept of activity "torn loose" from its own cultural-historical roots in the work of Vygotsky.

Davydov (1993, p. 53) advocates the development of a multi-disciplinary activity theory, one that combines the differences of emphases of the semiotically oriented researchers (based on Vygotsky's ideas) with those taking as their paradigm Leont'ev's conceptualisation of the activity aspect of human existence. Indeed, in Davydov's opinion, a "broad spectrum" approach (Davydov, 1993, p. 51) must be taken to solve the problems. That is, analysis must take place from a multi-disciplinary point of view. Only in this way, he feels, can we:

> shape our inheritance from the past in such a way that it can also serve us in the future.

Cole (1995b) reiterates Davydov's (1993) view that there has not yet been close cooperation on an international scale between those who take activity theory as their point of departure for analysis and those who use some version of Vygotsky's ideas with the emphasis on language and semiotics as mediation. He also comments that Russian adherents of these approaches have a different perspective on the differences which are bound up with the historical and ongoing "wrenching political upheavals of the region" (Cole, 1995b, p. 189).

Wertsch et al (1995, p. 6) distinguish between the terms "cultural-historical", or "sociohistorical", as used by Vygotsky and Leont'ev, and the heading "sociocultural" used by many Western researchers applying their approaches today. They feel that the first two terms are appropriate for referring to the heritage we have gained from the Russian psychologists, but that "sociocultural" expresses more closely the ideas as they have been appropriated in current Western research. For one thing, contemporary "sociocultural" scholars do not assume the "universalist" (Wertsch et al, 1995, p. 10) evolutionary claims for a linear progression of the development of the human psyche, which were common to Soviet thinking of the Vygotskian era, though not to Vygotsky himself. Also, a focus on consciousness and the internal workings of the mind was regarded with deep suspicion as "bourgeois idealism" by Soviet officials in power at the time (Bruner, 1985). This was one of the reasons why Vygotsky's work was banned for so long in his country.

As I have explained, Soviet psychology, grounded in Marxism, has a very different basis to Western psychology. Certainly, too, culture is understood differently in Western and Eastern perspectives. However, a focus on action and on mediation, common to the thinking of Vygotsky, Leont'ev and other Soviet psychologists, is considered to be defining of contemporary sociocultural research (Wertsch et al, 1995). However, Wertsch et al (1995) acknowledge that the roles of action and of mediation in human functioning are problematic. For example, the cultural tools actually invoked in an activity, were not necessarily designed for that purpose. Instead they may have been “dictated” by other sociocultural forces — and their benefits on mental functioning incidental (Wertsch et al, 1995, p. 26). For example, technology developed for military purposes has had enormous benefits for the development of civilian systems of communication and has facilitated innovation in other fields such as engineering and medicine.

The goal of sociocultural research has been defined (Wertsch et al, 1995, p. 11) as being to:

> explicate the relationships between human action, on the one hand, and the cultural institutional, and historical situation in which this action occurs, on the other.

Such relationships must include ambiguities, subject to interpretation and debate. This allows for multiple points of view and openness in investigation and analysis. These are essential if theory is to provide any tools for addressing human problems. My approach acknowledges these ambiguities and complexity of perspectives.

3.6 SUMMARY AND CONCLUSION

Activity theory provides a framework for understanding the processes of teaching and learning. It is described as a metatheory by Scribner (Tobach et al, 1997). While it cannot prescribe methods to be applied in specific instructional settings, it does provide a perspective for educators and researchers to see students, the learning context and the links between them in new ways. The activity approach provides insight into the roles of teachers. It suggests a view of students as active participators in their own learning — a view which, I think, fits with the intuitions of many teachers. It draws attention to the diverse ways students seek meaning within the cultural and social arena of their actions.

In my investigation, I draw on ideas of Vygotsky and Leont’ev and actualise them in a particular context. Firstly, I am focusing on the students’ activities in learning Statistics, as the students themselves report them — their actions and perceptions and how these relate to the contexts surrounding them. These activities implicitly include students’ goals and evaluations. A student’s understanding of Statistics involves her as a whole person. Secondly, I regard it as critical to understand students’ positioning of themselves within the arena of their actions. That is, I try to interpret how a student's activities orient her to the learning task in context. Moreover, while I am investigating each student's orientation to learning Statistics as a psychological profile for that individual, I consider this orientation to be simultaneously part of a wider, and dynamic, sociological event. Thirdly, I am trying to analyse systematically the relationships among the components of this "activity system" (Engeström, 1993, p. 66) — the acting students, the setting for the learning task and the wider cultures and society.

My approach extends activity theory in the way I view individual learning and knowledge. My view of these is more consonant with a theory such as enactivism (Varela et al, 1991) which emphasises the co-emergence of a student and her setting, rather than the induction of a student into a culturally predetermined structure. Vygotsky believed that individuals develop knowledge through being instructed. I believe that individuals and knowledge, such as mathematical knowledge, develop together through students engaging in tasks with socioculturally structured situations. These settings do not, however, necessarily include an instructor or instruction. This perspective emphasises knowledge and the student as mutually transforming.

In my two studies I bring to the foreground different aspects of the students' activities in the two studies. Other aspects remain in the background. At the same time, I acknowledge that the activity system of acting students and the arena of their actions is a functional whole. In Study One my focus is on individual's actions and perceptions as I explore the activities of five mature age students who sought my help with their learning of Statistics. In Study Two, I explore the perceptions and actions of a cohort of second year Psychology students. These students are regarded as a group within an institutional milieu and broader culture. In this study I try to analyse the emerging relationships amongst components of the students' orientations to learning Statistics: affective aspects, personal histories, conceptions of the subject matter and approaches to learning Statistics. My methodologies for these studies will be explained in the next chapter.

CHAPTER FOUR

RESEARCH QUESTIONS, DESIGN, METHODOLOGY, TOOLS AND METHODS

4.1 INTRODUCTION

My case study consists of two investigations. Study One is entitled “Exploring Mature Students’ Learning of Statistics”. In this study my aim is to tell the story of five students in a way that is generalisable to others — that is, I try to uncover recognisable truths from their narratives. Study Two is called “Understanding University Students Learning Statistics as a Service Course to Psychology”. This study is based mainly on a survey in which I tried to elicit students’ feelings about learning Statistics, their conceptions of the subject matter and their approaches to learning it. I also interviewed selected students and two academics involved with teaching Statistics.

4.1.1 Chapter Preview

In this chapter I describe my principal and sub-principal research questions, explain how I use a range of research tools to investigate them and describe some key features of my approach. I first present my research questions in Section 4.1.2. These are specified separately for Study One and Study Two. In section 4.2, I present some issues and controversies which are important to the current discourse on methodology in education research. I outline my methodology, that is, I explain the rationale for my ways of collecting and analysing data. I summarise the procedures that I followed. I indicate how I have attempted to satisfy criteria for good research as advocated by researchers such as Guba & Lincoln (1981); Kirk & Miller (1986); Merriam (1988, 1996); Miles & Huberman (1984, 1994) and Van Maanen (1983). In section 4.3, I explain how I “triangulate” (Lincoln & Guba, 1985) my results. I describe the modes of analysis I used in each of the two studies, drawing on Bruner’s two modes of thought (Bruner, 1986). I then present an overview of the methods I used in each of the two studies undertaken, in sections 4.4 and 4.5, respectively. That is, I describe the research setting, methods of data collection and methods of analysis for each study. In particular, I explain the assumptions underpinning the research specialisations, to use Marton's (1986) term (see p. 21) from which I developed my approaches. These research specialisations, or combinations of research orientations and research approaches, include naturalistic inquiry in Study One and phenomenography coupled with quantitative analysis in Study Two. In section 4.6, I consider ethical issues that I encountered and how I responded to them. I then discuss some dilemmas presented by my methods in section 4.7. Section 4.8 summarises and concludes the chapter.

4.1.2 Research Questions

The main research question which I investigate is:

> **What are students' orientations to learning Statistics ?**

As explained in the previous chapters, this question is important because, from an activity theory perspective, the way students orient or position themselves to learn is critical to the quality of learning that unfolds. That is, the ways students feel about learning Statistics, their conceptions of Statistics and their approaches to learning it reflect their engagement with the learning task — their activities. These activities are inseparable from the setting in which the students' learning is organised. They are shaped by and transform that setting in mutual and cyclic processes. The research question is specified as principal and sub-principal questions for each of the two studies. I will delineate these below, separately for each of the two studies.

4.1.2.1 Research Questions For Study One

In this study the research question stated above translates to the following question.

> **What can be learned about students' orientations to learning Statistics by exploring the perceptions, actions and evaluations of five mature students studying it?**

This question is divided into sub-principal research questions shown below.

1) What were the students' prior conceptions of mathematics and statistics based on their experiences of mathematical activities?

2) How did the students' perceptions of the context of the course mediate their goal directed actions?
3) What were the students' approaches to learning Statistics?
4) How did the students regulate and evaluate their experiences of learning Statistics?

4.1.2.2 Research Questions For Study Two

In the context of this study, the research question outlined at the beginning of section 4.1.2 is expanded to:

> **What are students' feeling about learning Statistics, conceptions of it and approaches to learning it and what are the relationships of these factors to each other and to other variables including gender and performance on assessment tasks?**

The survey, including the open-ended questions and Approaches to learning Statistics Questionnaire, referred to below, is reproduced in Appendix F.

The principal research question is separated into sub-principal research questions as follows:

1) What are the demographic or individual differences for the students participating in Study Two as indicated by the following variables: gender; age; fluency in English; degree for which enrolled; prior level of mathematics studied; prior level of statistics studied; intentions as to future study of Psychology and expected performance in Statistics and Psychology II.

2) What are the affective factors reported in response to the question:

> *Would you study statistics if it were not a requirement of your psychology course?*
>
> *Please give reasons for your answer.*

3) What categories of conceptions of Statistics emerge from students' written responses to the three open-ended questions in the survey, including the question:

What in your opinion is this statistics course about?

Please explain as fully as possible.

4) What are the students' approaches to learning Statistics as indicated by a questionnaire — the Approaches to Learning Statistics Questionnaire (ALSQ)?

5) What are the assessment results of the surveyed students?

6) What relationships can be found among the variables of interest?
   - In particular, I am interested in the relationship between the categories of conceptions and students' scores on the ALSQ.
   - More generally, I investigate the inter-relationships among the following variables:

   a) category of conception;

   b) willingness to study Statistics;

   c) scores on scales denoting surface and deep approaches to learning Statistics on the ALSQ;

   d) performance in tests and examinations;

   e) previous level of mathematics studied;

   f) age;

   g) gender;

   h) reported fluency in English;

   i) previous level of statistics studied.

4.2 RESEARCH DESIGN AND RATIONALE

In this section, which embeds my methodology in the literature and discourse surrounding education research, I explain the issues I explored and the assumptions and rationale that guided my planning and investigations.

4.2.1 Research Methodologies

Education research is the systematic investigation of educational phenomena:

> a mode of thinking rather than a shortcut to answers (Nisbet, 1980. p. 10).

Historically a spectrum of methodologies have been applied to education research. These include scientific experimentation, curriculum development, action research and ethnographic inquiries.

At one extreme of this spectrum are methodologies based on what Nisbet (1980, p. 3) terms the "agricultural model"— controlled experiments to improve the product. For a long time education research was dominated by this model which aspired to scientific precision in the behavioural sciences. Kerlinger (1979, p. 277) argues that science aims to "establish laws, systematic explanations or relations that apply generally". This paradigm is based on a positivist view of knowledge — that the truth exists and can be uncovered empirically by research (Kirk & Miller, 1986). Lincoln & Guba (1985, p. 19) suggest that this paradigm belongs to a "positivist era" of faith in science and the scientific method. Although we are now in a "postpositivist era", positivism has been "remarkably pervasive" (Lincoln & Guba, 1985, p. 28). Over the last two decades, however, there has been growing disenchantment in education research with methodologies rooted in this paradigm. One concern is that the very nature of the experimental method with its laboratory conditions and controls renders the educational situation artificial. This leaves the relevance of the results to educational practice open to challenge. Another issue concerns the uses and interpretations of inferential statistics, which underlie the experimental method in education research. For example, in recent editorials of the *Mathematics Education Research Journal*, Ellerton (1993, 1996) initiated debate and invited further discussion on statistical significance tests in education research. In this ongoing debate, the relevance of these statistical tests to the field of education is questioned (for example, in Batanero, 1997; Menon, 1993). Finally, the problems of replicability and generalisability are considerably more complex for human situations than for agricultural products. The context of any educational phenomenon is unique and multi-faceted.

For these and other reasons, there has been considerable movement in education research toward qualitative methodologies that involve open-ended inquiry — based on anthropological models or sociological models. This paradigm is loosely described by Nisbet (1980, p. 3) as:

> Go and live there and see what it is like.

Qualitative methodologies have interpretation and exploration as the rationale for data collection and analysis. Some major characteristics of qualitative methodology are described by Merriam (1988, pp. 19-20) as follows:

- the primary instrument is the researcher;
- the research involves natural settings or fieldwork;
- the results are qualitative description, that is "thick" rich text (Guba and Lincoln, 1981 p. 119) which gives depth to the experience;
- the inductive rather than deductive method is followed, that is abstractions are built from examples.

The methods by which qualitative research is expressed are diverse and may include interviewing, participant observation and content analysis as well as statistical analyses. To Kirk & Miller (1986, p. 10):

> Qualitative research is an empirical, socially located phenomenon, defined by its own history, not simply a residual grab-bag comprising all things that are 'not quantitative'.

To me the essence of the qualitative approach to research is the contextualising of the data. As Van Maanen (1983, p. 9) explains:

> The data developed by qualitative methods originate when a researcher figuratively puts brackets around a temporal and spatial domain of the social world.

This awareness of context implicitly signifies that the research framework is non-positivistic — the research cannot uncover laws about humans which apply at all times and places. This is particularly important for research inspired by Vygotsky's insights where human processes are "historically and socially determined" (Vygotsky, 1962, p. 23). In my investigation, the context in which students learn Statistics is a focus of my analytic understanding of their learning processes.

Gill (1996) points out the high degree of contestation over different research methods and research methodologies (defined by her as theoretical rationales for proceeding with a particular method). In particular there is rivalry between qualitative and quantitative approaches to research. Rather than dialogue or debate, Gill likens the rivalry to staking a claim in goldmining days:

> stake your claim of new ground and defend it by deriding all previous efforts (Gill, 1996, p. 33).

In particular, Gill finds the objection to quantitative approaches, (labelling them as narrow, impersonal or, pejoratively, as positivistic) troubling and usually irrelevant to the researcher’s actual purpose of justifying an appropriate qualitative method.

I agree with Gill (1996) that what is significant in any research methodology is the relationship between the findings and the theorising, rather than what research methods were used. If the assumptions underlying the data collection and analysis are poorly articulated then this relationship may not be well developed. For example, misunderstanding of assumptions underlying statistical analysis can lead to a reliance on numerical outcomes and the reporting of such numbers as ends in themselves. Much of the debate about the role of statistical tests of significance, which I referred to above, centres around the misapplication of statistical tests of significance. For example, these are sometimes misinterpreted as validating or invalidating the truth of a research hypothesis. However, poor research is no more inherent in quantitative methods than in qualitative methods. An uncritical acceptance of “highly individualised” narratives (Gill, 1996, p. 39) can be just as implicated in obscuring the situation of the research in its broader social context as an uncritical acceptance of numbers.

To Gill (1996) the adoption of a mixed methods approach is often more productive than a single line of inquiry. Further, Gill (1996, p. 37) suggests that:

> the schism in education research is a construction — and a construction that is fairly loose and somewhat insecure.

My position agrees with this. To me, different research methodologies have in common a search for meaning and understanding. The various research approaches are by no means mutually exclusive. Many education studies today use both controlled experimentation and qualitative exploration. Moreover, I believe that methodologies applying qualitative or quantitative methods are not even sharply separable. For example, the laws developed using quantitative methods are always statistical, that is concerned with variation — probabilistic. They are not absolute statements but conditional and uncertain. This is not only true of behavioural sciences, but also of the so called “exact” sciences, such as physics. Precision and objectivity are always a matter of degree. “Fuzziness” is inherent in all processes, be they movements of an atom or a student’s performance in an examination. Further, experimental results cannot be divorced from the researcher’s carrying out the observations, nor from the context in which he or she does so. In short, all analysis involves interpretation. Mathematical statements may seem impersonal and indisputable but their interpretation is embedded in the rich soil of human experience. Moreover, while, positivist “laws” hypothesise and test relations at the collective and abstract level, they are useful in assisting understanding of the profile and social experience of the individual. The metaphor of a spectrum of methodologies conveys the idea of shedding light. That, in the end, is surely the aim of any education research.

4.2.2 My Methodology

My primary aim is holistic and descriptive interpretation, aiming for depth of understanding. Consistent with a Vygotskian perspective, I consider the sociocultural context to be inseparable from individual actions. Hence my primary concern is to interpret the network of relationships between learner, subject matter and context. In attempting to make the data meaningful, I have drawn on various techniques of data collection and analysis. I have found it useful to combine qualitative and quantitative methods. Overall, my mode of doing research is consistent with what Lincoln and Guba (1985, p. 36) term the “naturalistic paradigm” in that I take as axiomatic that: realities are multiple; myself as researcher and my objects of research are inseparable; my working hypotheses are bound by time and context and all entities are in a state of mutual simultaneous shaping. Moreover, my inquiry is “value bound” (Lincoln and Guba, 1985, p. 161). That is, my investigation is bound by my assumptions, theories and perspectives and is regulated by both cultural norms and my individual beliefs. For example, my focus on the desirability of deep, rather than surface, approaches to learning (Biggs, 1979; Marton, 1988) and on personal development as part of the educational process reflects my commitment to these values.

The methodology I have used in this project is best described as case study research. Case study research does not claim any particular techniques for data collection or analysis (Merriam, 1988, Yin, 1992). It focuses on a clearly defined area of investigation — what Smith (1978, p. 356) calls an "instance of a more general class of events". The case study is appropriate when "interpretation in context" (Cronbach, 1975, p. 123) is essential to understanding the phenomenon under investigation. Yin (1992, p. 135) defines the case study to be:

> an empirical inquiry in which the number of variables exceeds the number of data points.

This means that the phenomenon under investigation is complex and bound up with the context, so that the important and interacting variables are too composite and too numerous to isolate and measure. Miles & Huberman (1994, p. 27) sometimes prefer the word "site" to "case" to emphasise that case studies take place in a specified social and physical settings. My design emphasises insight, discovery, description and interpretation within a bounded context.

As with any style of research, reliability, validity and generalisability are prime concerns. However these terms have different meanings according to the position of the researcher. In a positivist framework there is an assumption that there are "true" scores which, given a good enough instrument, can be measured reliably and with validity (Kirk & Miller, 1986). That is, the measuring instrument should capture accurately and with stability the true essence of what is being measured (Kerlinger, 1979). From a non-positivist perspective, however, there are no absolute truths or universal laws about human processes which can be captured. In such frameworks, the ways in which research findings are validated are socially construed. Constructs represent a consensus by the group concerned. This perspective suggests to me that the criteria for reliability and validity in education research depend on the recognition of the community of education researchers. These criteria are constituted by a convergence of social opinion about what is being investigated and how well this is done.

My understanding of social consensus as the basis for the research criteria accords with the qualitative approach to education research (for example, Lancy, 1993; Lincoln & Guba, 1985; Merriam, 1988, 1996; Miles & Huberman, 1984, 1994; Van Maanen, 1983). In particular, Merriam (1988; 1996) formulates questions about reliability, (internal) validity and generalisability (external validity) as they relate to qualitative case study research. These questions suggest criteria which fit with my framework. In what follows I describe these criteria and give an overview of my attempts to satisfy them. The details of how these attempts were carried out will be described in the context of Study One and Study Two.

Merriam (1996) formulates the question of reliability for qualitative case study research as being:

> Are the results consistent?

I have tried to provide a basis for recognition of consistency by means of different modes of "triangulation" (Lincoln & Guba, 1985, p. 305; Miles & Huberman, 1984, p. 234; 1994, p. 279). This surveying term, now commonly used in education research, was first appropriated by Webb et al (1965) who spoke of subjecting findings "to the onslaught of a series of imperfect measures" (Miles & Huberman, 1984, p. 234). This could suggest, however, that the perfect measure exists. In contrast, from my perspective, triangulation is about different ways of viewing a phenomenon, each of which is embedded in its own cultural and social context. Together, these ways provide a multi-faceted perspective on the phenomenon under investigation and better opportunities for understanding it than one method alone.

My modes of triangulation are listed below (see section 4.3.2.1, further on, for more details):

1. I used triangulation "between methods", that is different methods of data exploration. Both qualitative analyses and quantitative explorations were utilised to find congruencies and anomalies;
2. I also applied triangulation "within methods". For example, interview data was used to supplement, qualitatively, students' written responses to open-ended survey questions and I used a range of statistical analyses to explore patterns in the data;
3. My third mode of triangulation was triangulation "between investigators". I checked findings with fellow researchers, informally in discussions and formally by independent classifications and peer reviews.

The prime question of validity for case study research suggested by Merriam (1988; 1996) is:

> How credible are my findings given the data I have? Can others recognise that my conclusions are supported by the data?

I have tried to achieve internal validity by:

1. making overt my assumptions and procedures and laying an "audit trail" (Lincoln & Guba, 1985, p. 319) so making it possible for other researchers to follow how I got from the data to my findings;
2. making explicit the context, my personal biases and the theoretical framework;
3. suggesting and checking alternative explanations for my findings (Miles and Hubermann, 1994);
4. most importantly, submitting preliminary analyses for publication, or presenting my findings at conferences, thereby ensuring peer examination of my research.

In order to satisfy user or reader generalisability (external validity) that is to enable researchers to apply the findings to their own research, my aim is to make the data accessible — to create a virtual reality so that others can experience the phenomenon through my eyes. The passport to generalisability of my research is its "shock of recognition" (Adelman, Jenkins and Kemmis, 1976, p. 143) by others.

I have tried to achieve this by:

1. "thick" description (Guba & Lincoln, 1981, p. 119) facilitated by my personal and deep relationships with some of the participants;
2. diverse sites for comparison, namely the Mathematics Learning Centre (Study One) the Psychology II class (Study Two) and a General Statistical Methods class (pilot study: Gordon, 1995b);
3. inclusion of both unusual and "typical" members of the group being studied;
4. sampling to capture diversity within the project;
5. submersion in the research situation;
6. Making explicit the "transferable *theory*" from the investigation (Miles & Huberman, 1994, p. 279).

4.2.3 Grounded Theory

Beginning with Glaser and Strauss (1967) there has been much discussion of "grounded research", that is, the need for the research framework to evolve rather than to be imposed. In my case, a framework of beliefs, shaped by my teaching experience, previous research and interest in activity theory, resulted in my developing a loose theoretical framework early in the project. This was revised and changed at every stage of the research. Study One was explorative based on observations and intuitions gained by many years of teaching experience, in particular, teaching the Psychology students who attended the Mathematics Learning Centre for assistance in Statistics. The framework developed in Study One then served as the platform for developing the questions, hypotheses and procedures for the broader Study Two. This conceptual development is ongoing, informed by discussions and the act of writing this thesis and submitting research papers for review. Throughout the investigation, I have attempted to give a voice to the students. My analysis, though influenced by my experiences and by my interpretation of activity theory, is grounded in the perceptions expressed by the students.

4.3 ANALYSIS OF DATA

4.3.1 Criteria

Sieber (1976) suggests that good analysis usually involves the following:
Intertwining of analysis and data collection;
Formulating classes of phenomena — that is, categorisation of concepts;
identifying themes — linking concepts, noting regularities, patterns;
provisional testing of hypotheses — looking for concomitant variation, ruling out confounding factors, identifying intervening variables.

I attempted to meet these criteria in each of the studies (see section 4.4.4.3 for my analysis in Study One and sections 4.5.3.3 and 4.5.3.4 for analysis relating to Study Two).

4.3.2 Triangulation Using Qualitative And Quantitative Methods Of Analysis

Qualitative and quantitative analyses each have assets and liabilities. The aim of triangulation is to exploit the assets of each method while minimising the deficiencies of each. To me, the singular features of quantitative analyses are the level of abstractness at which the findings can be described (for example using mathematical equations) and the focus on pattern rather than detail. These generate a powerful way of communicating a complex and dynamic system. Quantitative data are useful for discerning distributions, trends, relationships and anomalies. The strengths of qualitative analyses are the very features lost in quantification — the richness and depth of description concerning the particular individual and context. As Weis (1968, p. 344) points out:

> Qualitative data are apt to be superior to quantitative data in density of information, vividness, and clarity of meaning.

My application of complementary methods of analyses produced opportunities for identifying consistencies within the data, thus enhancing my confidence and encouraging better definitions and enrichment of the description. They also produced surprises and anomalies. These led to alternative and deeper analyses and more insightful interpretation and understanding of the data. Most importantly, the complementary methods allowed for my immersion in the data. This resulted in my improved closeness to the data.

4.3.2.1 My Methods Of Triangulation

As a researcher, my task is to gain insights into the data by systematically interpreting their meaning. Different methods of inquiry were used in Study One and in Study Two to investigate the network of relationships relating to the research problem. These include holistic description and statistical explorations. In both studies I have triangulated the analyses "between" and "within" methods by using a variety of approaches both qualitative and quantitative in order to better describe and understand the problems in their contexts.

In Study One and in Study Two, "within methods" triangulation of the qualitative data included using material from interviews, surveys, informal observation and students' written work. Quantitative indicators, such as performance on assessments and demographic data, added another dimension to the descriptive data in both these studies ("between methods" triangulation). In Study Two, my triangulation "within methods" also included using a range of statistical analyses such as cluster analysis, factor analysis and correlations. The different ways of exploring the data in this study produced patterns and trends which indicated consistency. For example, the qualitatively different categories of students' conceptions of the subject matter, which emerged from students' responses to open-ended questions, were confirmed as having links to students' approaches to learning Statistics, analysed quantitatively, using scores on a Likert-type questionnaire (see Results, section 7.2). Strong relationships were found among the variables, such as students' conceptions of Statistics and their willingness to study it. Statistically significant trends converged with qualitatively significant differences between the categories.

Further triangulation for both studies was provided by "between investigator" analysis and interpretation. Here, discussions with colleagues at each stage of the two studies provided valuable feedback on my research design, interpretations of findings and conclusions. Some independent classifications and checks were also carried out on my categorisation in Study Two. For instance, students' conceptions of Statistics as reported in their surveys, were categorised by myself and, independently, by another education researcher (to be explained in section 4.5.5, below). Since this researcher is male, younger than me and has a different educational background, we brought very different perspectives to bear on the data. Discussions on the categorisation were held with a third researcher, allowing for further negotiation of different views. (See section 4.5.5 of this chapter for further details.) In addition, as explained earlier (in section 4.2.2) I consider it important to submit my work for publication as this enables me to experience peer reviews of each aspect of my project. A list of my relevant publications appears at the front of this thesis. This includes pilot studies and publications on preliminary findings, both for Study One and for Study Two as I carried them out. I will specify these in the context of each of the two studies, later this chapter (sections 4.4 and 4.5).

4.3.3 Modes Of Thought

I used a different genre for expressing my analysis in each of my two studies. In this I was influenced by Bruner's (1986) two modes of thought. Bruner (1986, p. 12, p. 13) calls these the "paradigmatic or logico-scientific mode" and the "narrative mode". The paradigmatic mode of thought is driven by "principled hypotheses" (Bruner, 1986, p. 13) which relate not only to what is observed but also to possible, logically generated worlds. This mode is the basis of science and is characterised by Bruner (1986, p. 12) as:

> attempts to fulfil the ideal of a formal, mathematical system of description and explanation. It employs categorization or

> conceptualization and the operations by which categories are established, instantiated, idealized, and related one to the other to form a system.

This is the mode of thought underlying my attempts to build up an "activity system" (Leont'ev, 1981; Engeström, 1993) by a methodical and logical relation of parts to a whole, guided by empirical discovery and "reasoned" hypotheses (Bruner, 1986, p. 13). In Study Two my style of reporting is consistent with this mode of thought. However, in Study One and in my overall "story", as I have termed it in Chapter One, I am also concerned with the narrative mode of thought. This mode is the basis of literature. As an art form it:

> deals in human or human-like intention and action and the vicissitudes and consequences that mark their course. It strives to put its timeless miracles into the particulars of experience, and to locate the experiences in time and place (Bruner, 1986, p.13).

The essence of this mode is the attempt to create gripping drama and believable accounts. It relates events temporally as well as by themes. It provides a basis for understanding individual actions and events as part of a unified "plot". I have no interest in creating drama but I do have a concern with the unfolding of particular students' experiences and the insights these provide into human conditions. In short, these two modes are both cultural tools, forms of which I have employed in my research activity.

4.4 STUDY ONE: EXPLORING MATURE STUDENTS' LEARNING OF STATISTICS

4.4.1 Rationale For Study One

A focus of my inquiry is to interpret and extend the theory of activity (Leont'ev, 1981) by describing the learning of Statistics as purposeful and interactive activity that develops in a sociocultural context. In this study I aim to capture some images which illustrate and develop the activity theory concepts outlined in Chapter Two and Chapter Three by providing examples of the activities of five mature students who attended the Mathematics Learning Centre for assistance with Statistics. As is the case for most students of the Mathematics Learning Centre, these students were at least 25 years old and had been out of the education system for a number of years. The rising number of older students in many universities means that research on their learning is becoming increasingly relevant and significant (Knox, 1986; Merriam & Caffarella, 1991). In addition, observations made by mature adult students are insightful and supply valuable material for stimulating reflections on teaching (Slotnick et al, 1993; Belenkey et al, 1986). The five students who were invited to participate in Study One were selected purposefully (Lincoln & Guba, 1985). As will be explained in Chapter Five (sections 5.2.1 and 5.2.2) these students had diverse life experiences, a range of academic backgrounds and singular personal attributes which led me to believe that their participation would be valuable to my research.

In short, I believe that an understanding of the perceptions, actions and evaluations of the participants of Study One is helpful in shedding light on important issues concerning students who study statistics at university as a service course, rather than by choice. In keeping with a qualitative research design, my analysis of this data is interpretative rather than explanatory, acknowledging the complexity of the issues faced and aiming to indicate the dimensions of that complexity, as well as to stimulate reflection and dialogue.

4.4.2 Model For Methodology In Study One

The design of this study reflects my consideration that the naturalistic paradigm (Lincoln and Guba, 1985) has the best fit to my aims described above. That is, in this study, with one exception, I have adopted the attributes of the naturalistic paradigm described below (Lincoln and Guba, 1985, pp. 39-43). The exception concerns my lack of adherence to grounded theory. What I studied was, to some extent, delineated in advance, informed by my understanding of activity theory (Leont'ev, 1981).

The attributes of the naturalistic paradigm are detailed below with a description of how I complied with each in Study One.

- **Characteristic 1: Natural setting**
  Study One was carried out in the Mathematics Learning Centre in the context of my teaching the five students during their second year of study of Psychology. All the students were regular and intensive users of the Centre and in some cases spent five or more hours per week working with me on their Statistics. Indeed the students frequently expressed the idea that they "lived in here" during their second year of study of Psychology. My

observations of them for the purpose of the study are inseparable from my actions designed to assist them with their learning.

- **Characteristic 2: Human instrument**
  I consider myself to be the primary data gathering instrument. That is, the evaluation of what the students said, did or wrote, is personal and subject to my own perceptions, beliefs and values.
- **Characteristic 3: Utilisation of intuitive knowledge**
  The study reflects my deep and warm relationship with the students. My analysis takes account of my experience of teaching them and others who have sought my assistance in learning Statistics.
- **Characteristic 4: Qualitative methods**
  Qualitative methods of data collection and analysis were used, namely descriptive and exploratory techniques aiming to illuminate multiple truths in context.
- **Characteristic 5: Purposive sampling**
  The students were not selected as being representative of any general group of students. Rather, as described above, it appeared to me that due to their singular characteristics (described in section 4.4.4.1) exploring these students' orientations to learning Statistics would be of value in understanding how students learn Statistics.
- **Characteristic 6: Inductive data analysis**
  I have tried to construct general themes from the particular examples provided by the students' accounts.
- **Characteristic 7: Grounded theory**
  I did not wholly comply with the description by Lincoln and Guba (1985, p. 41) of having "the substantive theory emerge from the data", as I was building on activity theory. However, as was explained in section 4.2.3, my theory evolved as the study unfolded.
- **Characteristic 8: Emergent design**
  The design unfolded as I observed the students. It was influenced by my interactions with the students. My research questions evolved from informal observations and intuitions. They were incorporated into the questionnaires completed by the students during their study of Statistics and thence into the semi-structured interviews conducted with the students after they had completed second year Psychology. Themes emerged in these interviews and subsequent interactions with colleagues and experts in education. The design

of Study One was only fully completed when I had written and revised a paper on the study for publication (Gordon, 1993c).

- **Characteristic 9: Negotiated outcomes**

  My interpretations were discussed with the five participants during their interviews and re-evaluated together with peers and other researchers. I also tested my working hypotheses in other studies (for example, in Gordon, 1994). I did not, however, ask the five participants to evaluate my interpretations of their interviews. I would have preferred to do so, but there were practical and ethical problems. By the time they were interviewed the students had already completed second year Psychology, and so had ended their association with me at the Mathematics Learning Centre. Not all of them were accessible to me afterwards. Also, I did not wish to exploit my personal relationship with the students by seeking their cooperation in my project beyond our negotiated agreement.

- **Characteristic 10: Case study reporting mode**

  I adopted this mode of reporting, also called the "narrative format" (Lancy, 1993, p. 231) in order to constitute the stories of the students, as I perceived them. In this way of reporting I was influenced by Bruner's (1986) narrative mode of thought, as explained above (section 4.3.3). This genre recognises the importance of description and context and is intended to make possible understanding on the part of the reader.

- **Characteristic 11: Idiographic interpretation**

  I make no claims that the study fulfils any general human condition. The data are interpreted in a particular situation and this interpretation is dependent on my personal perspective of the context.

- **Characteristic 12: Tentative application**

  While I hope that my research will be of value to other education researchers and to practitioners of teaching statistics, my findings are confined by temporal and physical boundaries — a snapshot of a situation. However, as outlined in section 4.2.2, I have taken what steps I can to ensure that the extent of transferability and applicability by others can be judged by others.

- **Characteristic 13: Focus-determined boundaries**

  The boundaries of this study are determined on the basis of the theoretical concepts which frame the study, and by the particular activities undertaken by the students in the social setting.

- **Characteristic 14: Special criteria for trustworthiness**

I have tried to meet the criteria of reliability, validity and generalisability as outlined in section 4.2.2. As was explained in this section, the aim of meeting these criteria is to enable my conclusions to be recognised and used by others.

4.4.3 Preparatory Research For Study One

Two preliminary studies (Gordon & Nicholas, 1992; Gordon, 1993a) informed Study One. The first investigation (Gordon & Nicholas, 1992) formed the basis of the initial data collection on four of the participants in Study One (see section 4.4.4.2, below, for description of data collection) This investigation addressed students' attitudes to and beliefs about mathematics and statistics. The students were surveyed during a bridging course in statistics. (I run this bridging course annually, during the vacation preceding the first semester of each academic year.) The course was advertised as a preparation for those students lacking the basic mathematical skills needed for their study of statistics in second year Psychology or for postgraduate courses in Public Health. The participants in the bridging course were self selecting: each of the 60 students enrolled felt poorly prepared for the statistics course which was a compulsory component of his or her chosen course. One interesting finding of this preliminary study related to differences in students' perceptions of statistics as compared to mathematics. In response to free association with the words "statistics" and "mathematics", students reported that statistics is "useful" (occurring 3 times as often in the students' associations with statistics as with mathematics) and statistics is "misleading" (no such responses for mathematics). Disraeli's saying: "Lies, damned lies and statistics!" evidently rings true for many people. Mathematics, on the other hand, was seen by these students as being either true or false. I took these perceptions into consideration in my analyses of Study One and of Study Two. That is, I paid attention to differences in the students' usage of the words "statistics" and "mathematics" in their written responses to open-ended questions and in interview data.

The second investigation (Gordon, 1993a) looked at the attributes and perceptions of Psychology II students who attended the Mathematics Learning Centre: their motivation for studying Statistics, their reasons for using the Centre, their background in mathematics and their evaluations of the learning environment. Correlations between the students' examination grades and their ages, prior levels of mathematics studied and performances in other areas of Psychology were addressed in this study. I discovered relevant questions to be addressed, for example: What were students' expectations about themselves as learners of Statistics? I also identified methodological issues from this investigation. For instance, I applied the "action research spiral" (Carr & Kemmis, 1986, p. 165) to this investigation (see p. 20 and Gordon, 1995a).

At the same time as building up the pragmatic and methodological foundations for Study One, I was building up a theoretical framework. This was based on the ideas of Vygotsky (1962, 1978) and Leont'ev (1969, 1978, 1981) as I have related. I applied their theories to the context of the Mathematics Learning Centre by illustrating the major features of the theory of activity with examples taken from my teaching practice (Gordon, 1994). I also developed a model for teaching these students based on my own, adult, experiences of learning to ice skate (Gordon, 1993b). In order to view the activity of learning Statistics from the students' perspectives, I related my own deficiencies in the three C's (composure, coordination and courage) needed for ice skating, to the students' feelings of inadequacies about themselves as learners of Statistics. I compared my ways of operating in the zone of proximal development (Vygotsky, 1978) with the support of the skating instructor, to the ways students learned to overcome their difficulties with my support. In these ways — by developing theoretical concepts, intuitive knowledge and metaphors for my teaching and learning, and submitting publications on these to peer review, I developed my themes and working hypotheses for Study One.

4.4.4 Method For Study One

4.4.4.1 Participants

Each of the five participants of Study One had exceptional attributes in some respect. The names I use below, to refer to the students, are fictitious but indicate gender. Norman, Sandra and Alice were extremely successful students of second year Psychology: Norman and Sandra both achieved High Distinction grades, a rank attained by only four percent (19 students) of their Psychology II class of 473 students, while Alice gained a Distinction for the course. Alice and Hettie had the unusual characteristic of not having studied mathematics at secondary school level at all. In fact Hettie's school education ended six months into secondary school, making singular her later academic achievements. Both succeeded in passing Statistics after a considerable struggle although both had high grades in other areas of the course. Four of these students were pursuing a study of psychology for vocational reasons. Ernest, on the other hand, was of an age where vocational interests are not relevant and was studying psychology to satisfy his intellectual curiosity. This resulted in his having a different attitude to his studies.

4.4.4.2 Data Collection

My data collection for Study One included informal observations made while participating in the students' learning, audio taped interviews, short surveys and questionnaires relating to the students' attitudes to and strategies for learning Statistics, the students' written evaluations of the teaching and environment of the Mathematics Learning Centre, demographic information and assessment results.

As is customary with qualitative research (Patton, 1980) my data consists of descriptions, direct quotations and excerpts, obtained by close psychological contact with those being studied. The major sources of these data were interviews conducted after the students had completed the course. (See Appendix A for a guide to the interview questions.) The students trusted me and were uninhibited in the interview situation. Some of the students' quotations which I report were obtained from questionnaires completed by them at various stages of the academic year and from their written notebooks.

My initial data collection consisted of survey responses of students taking a bridging course in statistics (described above, in 4.4.3). The survey is reproduced in Appendix B. Four of the participants in Study One (excluding Hettie) took part in this bridging course. My aim was to elicit the students' own understandings and perspectives instead of imposing my own ideas. Accordingly, at the start of the first session, without more than a brief personal introduction, the students were asked to respond freely with their associations to "mathematics" and "statistics". (See Free Association, Appendix B for the items to which students responded). These open questions were followed immediately by a more structured questionnaire (see Attitudes Questionnaire, Appendix B). From this investigation, I obtained an initial idea of the issues pertinent to the four students' views on mathematics and statistics.

Demographic information about the five participants and their reasons for seeking help in Statistics were obtained from their enrolment forms for the Mathematics Learning Centre. This was completed by the five students early in the first semester. An enrolment form is reproduced in Appendix C.

Throughout the year I observed the students informally, while I was engaged in teaching them individually, or while they were working in small groups in the Centre. As each of the students spent considerable and regular time with me according to their own needs, I had many opportunities to view their written work and to observe their strategies for learning. I spent considerable time interacting with them, both informally and in formal instruction. A survey consisting of an open-ended questionnaire and Likert-type items was completed by the five students in semester two (see Statistics Course Survey, Appendix D). Information on their evaluations of the Mathematics Learning Centre, as the setting for learning Statistics, was obtained from Mathematics Learning Centre Evaluation forms (see Appendix E) for the students, all of whom opted to sign their names on this survey.

After their final examinations in second year, at the conclusion of the academic year, I invited each of the students to come into the Centre for a long interview. According to Patton (1980) the purpose of the interview is to enter into the other person's perspective. To be successful, the interviewer must be neutral, that is non judgemental, and have rapport with the subject. The protection of the respondent must be ensured and ethical issues taken into account. The logistics of the interview must be worked out.

I based my interview questions on the activity theory framework and on my data analysis of the students' responses undertaken so far. The interview questions were designed to gain an in-depth knowledge of the students' goals, perceptions, attitudes and beliefs, relating to the Statistics course which they had recently completed. The interviews were semi-structured — I was guided by the list of questions shown in Appendix A, but neither the exact wording nor the order of the questions was precisely determined in advance. I allowed for feedback, interactive reassessment and probing. Furthermore, I took advantage of the students' relaxed frames of mind (with examinations over) and the interpersonal trust we had established, to follow up any unseen issues that arose in the course of the interview. I was also able to explore new openings suggested by the students' responses. In short, I acknowledged the sub texts of the conversations.

The interview questions were divided into four broad areas, as advocated by Patton (1980). These were about:

- behaviour or experience, for example
  Did any changes in your learning pattern occur during the year?
- opinions and values, such as
  How useful do you think what you have learned in Statistics will be to you?
- emotional responses and feelings:
  How did you feel about mathematics then (i.e. at school)?
- background demography, for example
  Have you done any mathematics or statistics since school, apart from your psychology course?

The ways in which the questions were framed included four modes, described by Strauss, Schatzman, Bucher, and Sabshin (1981). These are:

1) the hypothetical mode: for example —
   If Statistics had not been assessed, but nothing else changed, how would you have approached learning it?
2) the devil's advocate mode: for example —
   Some people would say, that if you can't cope with statistics you have no business doing psychology. Would you comment on that?
3) the mode of posing the ideal: for example —
   What to you would be the ideal statistics course?
4) the interpretative mode:
   What do you mean by ... ?/Could you explain ... ?
   I used this mode for probing.

The interviews were audio taped and I transcribed them myself, as a way of getting close to the data.

I also collected and read the students' notebooks in which they had made their own summaries of Statistics. This added further insights into each individual's ways of working and feeling. For example, Alice prefaced her written summary of a section she found difficult with:

> Analysis of Variance G-d help me!

The notebooks were returned directly and promptly to the students but (with permission) I retained confidential photocopies of illuminating sections.

4.4.4.3 Data Analysis

The aim of the data analysis is to tell the story of the five students in a way that could be recognised by other researchers and educators. As advocated by Sieber

(1976) each stage of the data collection was analysed and suggested further data collections and analysis in an ongoing cycle.

In the first level of analysis I arrived at categories of description, namely nodes or clusters of similar objects or characteristics, by reading systematically through the case records (of both written and verbal data) and finding patterns. In particular, the act of personally transcribing the audio taped interviews suggested categories of similar phenomena. Then I found units of information: for example, a sentence or notion that stood by itself, and I classified each into a category. In this way the categories were clarified and refined to ensure that they were, as proposed by Holsti (1969) and Merriam (1988), relevant, exhaustive, mutually exclusive, independent and formed from a single classification principle. The categories I arrived at were: demographic information; students' goals with respect to learning Statistics; their perceptions of school mathematics; perceptions of "real life" statistics; perceptions of context in the activity of learning Statistics and approaches taken to learn Statistics. The categories were entered on a database as a precursor to my writing an integrated and interpretative description. That is, from the earliest stage of analysis, my database was a narrative, intended to be read by an audience of educators. Each stage of the analysis corresponded to a refinement of this narrative — from disjointed elements, through motifs to a unified whole.

The second stage of the analysis was to identify themes which connected the categories. The themes were derived from what the students said — common threads in the interview data. These were analysed in terms of Leont'ev's (1981) breakdown of activity into three levels: the milieu or social setting of the activities, the goals directing the actions and the operations or automatic components of the actions (as described in Chapter Two). One major theme which emerged, relates to students' evaluations and self regulation of the task of learning Statistics.

The next step was to formulate working hypotheses. These were outlined in Chapter One and are reproduced below for the convenience of the reader.

- The students identified two different sorts of statistics or mathematics — school mathematics and "life" statistics or mathematics.
- Actions were goal directed.

- The students' approaches to learning Statistics were related to how they positioned themselves with respect to the learning task.
- The students' metacognitive processes of monitoring and evaluation were paramount in defining their activities.

The last stage of analysis involved integrating my interpretations and explanations into a coherent description as shown in Chapter Five. The results of this study served as the starting points for Study Two.

4.5 STUDY TWO: UNDERSTANDING UNIVERSITY STUDENTS LEARNING STATISTICS AS A SERVICE COURSE TO PSYCHOLOGY

4.5.1 Setting For Study Two

The setting for Study Two is the class of students studying Statistics as a compulsory component of Psychology II at the University of Sydney in 1995. All the participants had studied a short (5 week) introductory course in statistics in Psychology I. The students completed the survey during a Statistics lecture, and had by this time written two Statistics class tests. The excerpts reported are written expressions from this survey and vignettes from interviews conducted after the survey, later that year.

4.5.2 Grounding For Study Two

Study Two is grounded in Study One. The results of Study One were instrumental in determining the questions to be answered for the whole cohort of Psychology II students. The methodology owes much to my previous research projects, in particular, a pilot study (Gordon, 1995b) described below and collaborative research on the learning experiences of mainstream mathematics students (Crawford, Gordon, Nicholas & Prosser, 1994a; 1994b; 1995; 1998).

A pilot study was conducted by surveying 52 students entering second year Psychology and 59 Arts students starting a first year general statistics course (published in Gordon, 1995b). In this survey, I asked students to report on their reasons for studying statistics, their expectations of their courses and their usual approaches to studying mathematics. These responses were elicited by three open-ended questions shown below.

Question 1 differed for the Psychology students and the General Statistical Methods students because statistics was an elective for the latter group. The Psychology students were asked to respond to the following question:

> *Would you study statistics if it were not a requirement of your psychology course?*
>
> *Please give reasons for your answer.*

General Statistical Methods students were asked the following question:

> *Why did you decide to enrol for this course in statistics?*

Both groups were asked to respond to the following two questions:

> *What do you expect this statistics course at university to be about?*
>
> *How do you usually go about learning some maths?*

The students surveyed in this pilot study were starting their statistics courses and many had little or no experience of studying statistics, as distinct from mathematics. Hence I did not ask about their usual methods of studying statistics.

I identified categories of description for the students' responses to each of the above questions. These were discussed with a colleague (Ms Mary Barnes) experienced in education research. This researcher also, independently, classified each response. We then discussed our classifications and reached agreement on all classifications. The results showed that those who chose to study statistics were motivated primarily by perceptions of the relevance of the knowledge. In contrast, personal and negative evaluations of mathematics dominated the responses of those unwillingly studying a compulsory course in statistics. About half the students surveyed expected their statistics course to provide a tool; most of the others focused on statistical processes. Disturbingly, almost 80% of them reported surface approaches to learning mathematics.

The three open-ended questions (above) from the pilot study were modified in Study Two. In this study I tried to ascertain students' conceptions of Statistics during their study of Psychology II, rather than investigating the expectations of students entering Psychology II about Statistics, as was the case in the pilot study.

4.5.3 Method For Study Two

All second year Psychology students attending a Statistics lecture were asked to complete a questionnaire on their conceptions of Statistics and their attitudes and approaches to learning it. Interviews with selected students were carried out during the following months while analysis of the survey was ongoing, in order to flesh out and clarify the findings emerging from the participants' written responses. The participants, my methods of data collection and procedures for data analysis are explained in the sub-sections of 4.5.3 below.

I presented my preliminary findings at an international conference, the 20th Conference of the International Group for the Psychology of Mathematics Education. (Gordon, Nicholas & Crawford, 1996). Feedback from this presentation was used to refine the analysis. I gained further feedback on my ongoing analysis at an Australian symposium on research methodologies (Gordon, 1996) and at the 20th Annual Conference of the Mathematics Education Research Group of Australasia (Gordon, 1997b).

4.5.3.1 Participants

The survey was completed by 279 students. The majority (73%) of these participants were female. Most of the students were 19 years old (48%) or 20 years old (18%). Full details about the participants will be given in Chapter Six (section 6.2).

4.5.3.2 Data Collection

A. Written Data

The survey was completed during twenty minutes of a Statistics lecture near the end of the first semester (in week 12 of 14 teaching weeks). As can be seen in Appendix F, the survey includes questions relating to demographic variables such as age, gender and prior level of mathematics studied, three open-ended questions and a Likert type questionnaire — the Learning Statistics Questionnaire. The Approaches to learning Statistics Questionnaire (ALSQ) consists of items from the Learning Statistics Questionnaire as will be explained in sections 4.5.6 and 6.5.1.

I personally explained the research to the students and asked them to assist by participating in the research. I then presented the survey papers to the students, with the help of three assistants. Students were asked to detach and keep the information sheet (see front page of survey). To ensure confidentiality, all surveys were given a code number. The last sheet, containing the names and telephone numbers of students who were willing to be interviewed, was coded with the same number, detached and kept in a separate and secure place. Test and examination results were publicly available from the departments concerned. These identify students by their Student Identification Number only, that is, no names are supplied on the lists that are publicly available. Hence I could, and did, only access the marks of students who had given their permission for this to be done by supplying their Student Identification Number on the survey.

B. Interviews — Vignettes

In Study One, interviews were the primary sources of data. However, in Study Two, interviews with students served only to illustrate and clarify aspects of students' written survey responses. Hence it was my aim to interview few but carefully selected students. Approximately one third of the surveyed students supplied telephone numbers indicating their willingness to be interviewed. This meant that I had a large pool from which to select prospective interviewees. It also indicates a high degree of engagement with the research by the participants so enhancing the richness of their written responses.

Seven students of Statistics were interviewed. These were selected because they gave diverse survey responses both in terms of what they wrote and how engaged with the issues they seemed. In particular, I interviewed students with different attitudes to learning Statistics, conceptions of Statistics and approaches to learning it — as far as I could judge at the time from my ongoing analysis of the three open-ended survey questions. I also ensured a range of values on variables such as age, gender and background in mathematics. I interviewed some who wrote a lot, or expressed themselves passionately, and some who did not articulate much of their thinking. During the period in which I conducted interviews no assessment marks were available to me, nor had I commenced analysis of the Approaches to Learning Statistics Questionnaire.

Extracts from six interviews are quoted. Lengthy extracts from two interviews are included in Chapter Six (section 6.7). These flesh out the written responses of these two students. Short vignettes from four other interviews are included in Chapter Seven (section 7.3.2.3) to illustrate four different student profiles identified. The interview data from the seventh student is not included as it did not provide any additional clarity nor shed new light on the findings. I also interviewed two academics. For the sake of maintaining confidentiality, I will refer to them only as teachers of Statistics. Their perceptions are recorded in Chapter Eight. Guides to the interview questions for students and teachers are shown in Appendices H and I respectively. However, these show “seed” questions only. The interviews were unstructured. I attended carefully to what the individual interviewees were saying and followed up on the issues which seemed important to that person or provided me with new insights.

4.5.3.3 Summary Of Procedures For Data Analysis

In this section, I outline the procedures I followed to analyse students’ responses to the survey. The sections below (4.5.4, 4.5.5 and 4.5.6) fill out this overview by specifying the details for each portion of these analyses.

1) For each variable relating to personal differences, including sex, age and prior level of mathematics studied, I defined categories and then coded these numerically. For example, I identified six hierarchical levels of prior mathematics studied by the participants: LESS THAN YEAR 12, 2 UNIT MATHEMATICS IN SOCIETY, 2 UNIT MATHEMATICS, 3 UNIT MATHEMATICS, 4 UNIT MATHEMATICS, UNIVERSITY MATHEMATICS. The middle four of these relate to the Higher School Certificate (highest school examination) in the Australian state of New South Wales. (This will be explained further in Chapter Six, section 6.2). Some of these categories were further divided into sub-categories.
2) I analysed students’ willingness or reluctance to study Statistics from their responses to Question 1 of the survey. Initially I defined a dichotomous variable CHOICE: YES or NO. Then I classified students’ reported reasons for their choice. More details are provided in section 4.5.4, below.
3) I categorised students’ conceptions of Statistics using a phenomenographic approach as outlined in Chapter Two (section 2.3.2.1). Five main categories were obtained (some with sub-categories) from their responses to the open-ended questions. I will explain my method fully in section 4.5.5 below. Further clarification is provided in the Results of Study Two (section 6.4).

4) I analysed students' approaches to learning Statistics as indicated by their scores on two scales, the Deep Scale and Surface Scale of the Approaches to Learning Statistics Questionnaire (ALSQ). The ALSQ was derived from Biggs (1987) and modified by my colleagues and myself in previous research (Crawford et al, 1995, 1998). My construction of these scales and checks on their reliability coefficients are explained in sections 4.5.6 and 6.5.1.

4.5.3.4 Higher Levels Of Analysis: Developing Relationships And Themes

I analysed students' survey responses to explore the inter-relationships among the variables. That is, I explored the relationships among students' conceptions of Statistics (as categorised) their scores on the Deep and Surface Scales of the Approaches to Learning Statistics Questionnaire, their expressed willingness to study Statistics, their attainment in tests and examinations on Statistics, and various demographic and individual difference variables, such as gender and prior level of mathematics studied. Strong patterns and relationships were found. These will be discussed in Chapter Seven.

The data collection and analysis was not a linear process. I was interviewing students at the same time as I was analysing the survey responses. Each stage of the analysis and data collection resulted in my reviewing the earlier stages and, in many cases, rethinking my conclusions and proposing new hypotheses. For example, my analysis of data on students' marks which became available at the end of the year guided me to new insights about the students' experiences. My exploration of students' responses also suggested questions about teachers' perceptions and led to my interviewing two teachers of Statistics. Themes emerged — such as the relation between students' "personal sense" (Leont'ev, 1978, p. 92) of Statistics and the meaning of Statistics as collectively understood. I synthesised the themes arising from Study Two with those of Study One. This will be explained in Chapter Nine.

4.5.4 Analysis Of Students' Appraisals Of Learning Statistics

This section outlines the method used to analyse the first open-ended survey question:

> *Would you study statistics if it were not a requirement of your psychology course?*

Please give reasons for your answer.

As I specified above (section 4.5.3.3) the first part of the above question was simply analysed in terms of whether the student answered "Yes" or "No".

The reasons that students gave for their choice were categorised in the following way.

1. I started with the categories that had been identified in my pilot study (Gordon, 1995b). However, I expected that differences would emerge in Study Two. The pilot study had been carried out three years earlier. A different lecturer taught Statistics then and the pilot study was conducted at the beginning of the academic year, so that students had less experience of Statistics than the participants in Study Two. Moreover my pilot study sampled not only Psychology II students but also students of General Statistical Methods. Nevertheless, many of the same categories were found to be useful for Study Two.
2. Most students gave several reasons for their decisions. For example, some students who reported that mathematics was boring also believed that it was hard. I classified each portion of the student's response into one of the specified categories. If the student gave a reason which indicated a negative view, I assigned her a score of –1 for the appropriate category. I assigned a score of 1 for favourable observations. If the student made no response in a particular category, a score of zero for that category was allocated. In this way students could have non zero scores in a number of categories.
3. Each student scored either –1, 0 or 1 for each of the categories. Hence the total number of favourable responses (with score: 1) and unfavourable responses (with score: –1) in any one category (for example, INTEREST) was equal to the number of students whose reported reasons were classified in that category. The distributions so obtained will be discussed in Chapter Six, section 6.3.1.
4. If the student's response did not fit into any of the categories identified so far, a new category was specified.
5. When all 279 surveys had been classified, some of the original categories were found to be empty and dropped.

4.5.5 Analysis Of Students' Conceptions Of Statistics

I based my analysis of students' conceptions of Statistics on the modifications of the phenomenographic method that were developed in earlier research by my colleagues and myself (Crawford et al, 1994a; 1994b). As was the case in those investigations, the categories of description and their patterns of distribution are considered to be major results of Study Two. They will be described in detail in Chapter Six (section 6.4).

The phenomenographic analysis of the data on students' conceptions involved three stages. In the first stage the categories of conception were identified. The second stage consisted of classifying the 279 surveys into these categories. In this process the categories were clarified and refined. In the third and later stage I checked each survey response to pick out any that I felt had been misclassified and submitted these to further examination and discussion.

4.5.5.1 Stage One: Identifying The Categories Of Conception

The first stage in the analysis of the data was to identify a set of qualitatively different categories of description of students' conceptions of Statistics.

This involved the following procedure:

1. An initial set of categories was identified by myself and another education researcher, Mr Peter Fletcher, experienced in phenomenographic research (Fletcher, 1997). This was achieved by our independently reading and classifying the entire set of 279 written responses to the open-ended question below:

    What in your opinion is this statistics course about?

    Please explain as fully as possible.

2. We two researchers then compared and discussed our initial categories and agreed on a draft set of categories and sub-categories.
3. Together with a third researcher, we independently classified 30 selected responses in terms of this draft set of categories.
4. The three of us compared and discussed the individual classifications for the 30 responses and agreed on a final set of clear statements for each category.

The categories were arrived at by negotiation and discussion. We looked at commonalities in the students' responses and differences between them.

4.5.5.2 Stage Two: Classifying The Surveys

All 279 responses were then classified into the identified categories by myself and my co-researcher, working independently. This classification was done in the following way.

1. For each student the response to Question 3 (repeated below for the convenience of the reader) was read in isolation to the rest of her survey.

   What in your opinion is this statistics course about?

   Please explain as fully as possible.

   An initial decision was made as to the category the response best fitted. I was mindful of the fact that, although I had phrased the question in order to elicit the student's own perception of the subject matter, some students were likely to interpret the question as asking about their perceptions of the teacher's view of Statistics, rather than their own awareness. For this reason the initial categorisation was modified by means of steps 2 and 3 described below.

2. Each of us re-appraised our initial decisions in the light of students' responses to the other open-ended questions, namely:

Question 1	*Would you study statistics if it were not a requirement of your psychology course?*
	Please give reasons for your answer.
Question 2	*Think about the statistics you've done so far this year.*
a)	*How do you go about learning it?*
b)	*What are you trying to achieve?*

In this way we amplified our understanding of each student's awareness and perceptions of Statistics and gained further insight into her way of experiencing the knowledge. We individually recorded a final category for each student's conception of Statistics by taking account of the student's overall responses to all three open-ended questions. The initial category that had been identified from Question 3 alone played no further part in the analysis, but was found to be very useful in the ensuing discussions between myself and fellow researchers in making explicit the reasons for the final categorisation.

3. We then discussed all classifications and reached agreement on any that did not match.

In this process of classification and discussion the categories themselves were further clarified. That is, as Marton (1986, p. 43) explains, the analysis:

> is dialectical in the sense that meanings are developed in the process of bringing quotes together and comparing them.

Not only core meanings are important in specifying the categories, but, as Marton (1986, p. 43) points out, “borderline cases” play an important part in delineating the categories. In accord with Marton’s phenomenographic method, the categories transcended the boundaries between students’ responses to different questions and also transcended the boundaries between individuals (Marton, 1986). That is, the students’ separate responses to different questions and their individual ways of expressing themselves were subsumed into general categories.

4.5.5.3 Stage Three: Triangulation And Checking

Triangulation on the analysis of students’ conceptions of Statistics was achieved by:

- Interpersonal agreement between at least two researchers;
- Interviewing selected subjects;
- Peer review. As explained in the introduction to section 4.5.3, I presented my ongoing analysis at three research conferences, conducted approximately six months apart. In this way I obtained feedback on my ideas, methodology and findings as my study progressed.

After a period of some months I read through all the responses, one category group at a time. On the basis of the better understanding of the data now available to me, for example through interviews, I discovered a few responses that appeared to me to have been misinterpreted in earlier discussions. These were further discussed with my colleague and reclassified in some cases.

4.5.6 Development Of The Approaches To Learning Statistics Questionnaire (ALSQ)

The Approaches to Learning Mathematics Questionnaire (Crawford et al, 1995; 1998) and the Approaches to Learning Statistics Questionnaire (ALSQ) were derived from the two scales of the Study Process Questionnaire (Biggs 1987) which denote surface and deep approaches to learning. While the Biggs' scales purport to investigate approaches to studying in general, the Approaches to Learning Mathematics Questionnaire investigates students' approaches to learning mathematics, as a generic field of study. That is, in the Approaches to Learning Mathematics Questionnaire, the wording of Biggs' deep and surface scales was changed to refer to approaches to learning mathematics, rather than to studying in general (in Crawford et al, 1995; 1998). My Learning Statistics Questionnaire (in Appendix F) from which the items of the ALSQ were selected, was modified from of our Approaches to Learning Mathematics Questionnaire by changing "mathematics" to "statistics" in the items. As can be seen from Appendix F, the Learning Statistics Questionnaire refers to students' approaches to learning Statistics — as a particular subject studied for Psychology II. Hence the three questionnaires: the Study Process Questionnaire (Biggs, 1987); the Approaches to Learning Mathematics Questionnaire (Crawford et al, 1995; 1998) and the ALSQ (Study Two) represent a progression — each focusing and particularising the constructs of interest in previous investigations.

The Learning Statistics Questionnaire completed by the Psychology II students contains 28 items on approaches to learning Statistics (see Appendix F). The 14 odd numbered items were derived from items in the previous questionnaires indicating a surface approach to learning and the 14 even numbered items were derived from the scales denoting deep approaches to learning. For each item a choice of responses numbered 1 to 5 was provided. The lower end indicates that the student "only rarely" adopts this approach when studying Statistics, while the upper end indicates that the student "almost always" does so. Hence, a student's score on each subscale signifies how usual it was for her to adopt the specific approach (deep or surface) to learning Statistics. I carried out item factor analyses and scale reliability analyses in order to determine the structure and internal consistency of the items. These analyses will be described in Chapter Six, section 6.5.1. As a result of these analyses the ALSQ was defined as consisting of 18 items, twelve making up the Deep Scale and 6 items constituting the Surface

Scale. Scale validity of the ALSQ is indicated by relationships with other variables such as willingness to learn Statistics (see section 6.5.2).

4.6 ETHICS

This study was approved by the University of Sydney Human Research Ethics Committee.

In order to ensure that I fulfilled my ethical obligations to the students and academics participating in my research I addressed the following issues.

- **Voluntary participation**

  a) Survey

  In the case of the survey, I invited students to participate both verbally and in writing (see page one of the survey). I explained the purpose of the research and how their responses would be used. Students who did not wish to complete a portion of the survey, or indeed the whole survey, were at liberty to desist. A few students omitted to give their Student Identity Number and one person (that I am aware of) refused to complete the survey. No pressure was brought to bear on them.

  b) Interviews

  Only students who gave their written consent to be interviewed were contacted by telephone. All interviews took place on a face to face basis and were audio taped. Hence the participants were able to see when the tape recorder was running, and I invited them to switch the recorder off at any time if they so wished.

  I asked students to sign a consent form (reproduced in Appendix G). I also signed this form assuring the student of confidentiality and explaining again the purpose of the research. During the interview each participant was given the opportunity to ask any questions and discuss any difficulties relating to Statistics. Some students took this opportunity to ask questions relating to the course content, the assessments (which I was unable to answer) or my research. Students were offered full editorial rights over the transcript of their own interviews. None opted to take advantage of this offer.

- **Disclosure of my aims**

  I informed all participants of my aims: in writing, on page one of the survey, on the interview consent form, and verbally. Teaching staff were invited to discuss the research with me at various stages of preparation for the project and analysis.

- **Guarantee of confidentiality**

  All students and staff participating in my research were guaranteed confidentiality. False names are used throughout. As recognition of students by staff members close to them is impossible to prevent, no excerpts from students' interviews were published during the year the students were in Psychology II.

- **Access to marks on tests and examinations**

  As explained in section 4.5.3.2, I only accessed a student's marks if she consented to this.

- **Opportunity to complain of any ethical misconduct on my part**

  Students were given written information as to whom any complaints or reservations about any aspect of their participation in this research could be addressed. They were asked to tear off and keep the first page of the survey in order to maintain their access to this information.

- **Taking account of power structures**

  As a staff member of the Mathematics Learning Centre, I have no input whatsoever over students' grading and am not involved with tests and examinations in any way. Similarly I have no authority over other academics. As outlined in Chapter One, my job is to assist students at their own behest with any subject at The University of Sydney which involves elementary level mathematics and statistics. Students and teachers were invited to assist me by participating in this research.

4.7 DILEMMAS

- My first dilemma concerns the invidious “p<0.05”. What does this mean for a non random sample? I am not trying to generalise to some population — my sample is from a hypothetical and undefined population, perhaps of students’ responses at different times. Further, statistical tests of significance do not answer the interesting and relevant question: “Is there a low probability that the results occurred by chance?” or more precisely “What is the probability that the null hypothesis (of no effect) is true given the results I have observed?” Instead they answer the far less critical converse question, namely: “What is the probability of getting the observed results (or even more extreme effects) assuming that the null hypothesis is true?”. Hence my use of these tests does not make my results more credible. They cannot be used to evaluate the educational significance of the result nor to ensure trustworthiness, in the positivist sense of reliability or replicability.

  I am using these tests simply as flags, signalling that something may be worth qualitative interpretation and investigation or suggesting directions for future research. Statistical significance is important if it converges with educational significance, or signals an anomaly. I will review my interpretation of statistical analyses in Chapter Ten (section 10.3.2.2).

- My second problem concerns the contextualising of phenomenography. As I pointed out earlier (at the end of section 4.5.5.2) phenomenographic categories are “clean” categories in the sense that they ignore the boundaries between an individual’s responses to different questions and they also “abandon” boundaries between individuals (Marton, 1986, p. 43). The categories become generalisations in which idiosyncratic diversity and contextual specificity is lost. Yet each person’s responses are embedded in her personal history as well as the context in which the response is made. I can only acknowledge this paradox and suggest that development of phenomenographic methods is needed to take into account personal and contextual divergence in the categorisation of conceptions.

- Are students in a position to assess their own perceptions, especially in a situation where there is limited time? If they had the surveys to take home and think about, their responses would surely have been very different. On the other hand, did the spontaneity occasioned by students responding immediately to a question result in more honest responses?

4.8 CONCLUSION

The aim of research is to illuminate the phenomena under investigation. To do this, a spectrum of methodologies is available to the researcher. Methodologies are not defined by the types of data collection or analytic techniques deployed but by the purpose of the investigation. In this research my aim was to understand students' orientations to learning Statistics from their own perspectives, taking into account the context of their responses. The research tools I used depended on the questions I wanted to answer. In Study One these required exploration, rich description and qualitative interpretation. In Study Two, the questions required a more systemic analysis, involving categorisation of concepts, distributions, patterns and relationships. By using a variety of methods of data collection and analysis I have endeavoured to shed light on some aspects of the complexity of learning Statistics.

CHAPTER FIVE

RESULTS OF STUDY ONE: EXPLORING MATURE STUDENTS' LEARNING OF STATISTICS

5.1 INTRODUCTION

My aim in this study is to gain some preliminary insights into the issues pertinent to students' learning of Statistics by exploring the perceptions, actions and evaluations of five mature students who sought help from the Mathematics Learning Centre. I apply and illustrate the theoretical concepts outlined in Chapter Two and Chapter Three by providing examples of students' statistical activities.

5.1.1 Chapter Preview

In this chapter I explain the findings and conclusions of Study One. Below in section 5.1.2, I summarise the background to the study and recap the research questions. In section 5.2.1, I give some details about the participants' backgrounds and achievements. The following section (5.2.2) illustrates the students' conceptions of mathematics and prior expectations of Statistics which reflect their experiences. I then interpret the students' goals in their cultural and institutional settings as the "energisers" (Leont'ev, 1981) of their actions, in section 5.2.3. I describe, in section 5.2.4, how their differing approaches to learning statistics unfolded, how these related to the students' perceptions of the situations framing their learning and how they positioned themselves with respect to the learning task. The chapter then explores the ways in which the students' evaluations and reflections regulated their activities (section 5.2.5). I conclude by summarising the findings in terms of the research questions (section 5.3.1) and proposing questions raised by this study (section 5.3.2). These questions serve as the basis of the investigation in Study Two.

5.1.2 Background To Study And Recap Of Research Questions

It is important for students to do well in Statistics which currently carries the substantial weighting of twenty five percent towards the overall aggregate for Psychology II at The University of Sydney. A five week introductory course in statistics is taken by Psychology students in first year, but it is considered that the second year study lays the foundation in basic statistics that Psychology students are required to master. Further, entry into the Honours strand of Psychology III, which is required for post graduate courses in Psychology, is highly competitive. For students who lack the background in mathematics, or are not confident about their ability to learn a mathematical subject, the study of Statistics poses special problems.

The participants of Study One were highly engaged in the task of learning Statistics. Four of them intended to attain higher degrees or work in the field of psychology. The fifth, Ernest, had retired from work and was studying psychology for his own self fulfilment. The five students grappled with the problems posed and applied themselves to the task of overcoming difficulties in ways that were individual and yet reflected the commonality of the learning task and of the setting confronting them.

The research questions for this study, delineated in section 4.1.2.1, are repeated below for the convenience of the reader.
The principal research question is shown below.

> **What can be learned about students' orientations to learning Statistics by exploring the perceptions, actions and evaluations of five mature students studying it?**

This question is divided into the following sub-principal research questions.

1) What were the students' prior conceptions of mathematics and statistics based on their experiences of mathematical activities?
2) How did the students' perceptions of the context of the course mediate their goal directed actions?
3) What were the students' approaches to learning Statistics?
4) How did the students regulate and evaluate their experiences of learning Statistics?

Wherever possible in the following narration, I have used the students' own words, transcribed from the interviews I conducted with each of them at the end of the year, or quoted from the surveys they completed. In this way I have tried to reveal their worlds.

5.2 FINDINGS OF STUDY ONE

5.2.1 Background And Attainments Of The Participants

The five students came voluntarily to the Mathematics Learning Centre hoping to overcome what they saw as difficulties or disadvantages that would affect their learning of Statistics. Alice wrote on her enrolment form (shown in Appendix C) that she had no mathematical skills or background, while Norman expressed the view that he was out of practice; it had been seventeen years since he last did any mathematics. Sandra indicated on her form that she required further explanation and repetition of tutorial material to aid her in understanding and clarifying the concepts. She also hoped to increase her confidence in her ability to understand Statistics. Hettie displayed considerable distress at the beginning of the academic year. She wrote that her reason for enrolling with the Centre was that she found:

> the statistics component of Psych. II very intimidating, almost incomprehensible!

A lack of confidence was also demonstrated by Ernest who wrote on his enrolment form:

> I feel that I need <u>all</u> the help I can get.

The assessments in Statistics completed by the five students consisted of one tutorial test or quiz and one examination in semester one and a quiz and examination in semester two. The tutorial tests were open book tests in which problems involving statistical analyses were posed. The examinations at the end of each semester took the form of forty multiple-choice questions. The scores on these four components were equally weighted to obtain the final mark for the year in Statistics.

Table 5.2.1, below, provides evidence of the exceptional nature of this group, as I have already outlined in section 4.4.4.1. The table summarises the level of mathematics studied at school (in Australia or overseas) by the five students, the final grades obtained by them in Statistics, their grades in the non-mathematical components of second year Psychology and their final grades in Psychology II. As can be seen from this table, these students achieved success in their attainments for Psychology II. As is often the case for older students, life experiences, coupled with high motivation, disciplined study habits and effective communication skills, helped these students in their study of psychology. Their lack of preparation in mathematics, however, meant that considerable difficulty was experienced by the five in Statistics. This was especially the case for Alice and Hettie who had not studied algebra at all.

TABLE 5.2.1
PRIOR LEVEL OF MATHEMATICS STUDIED AND ATTAINMENTS IN PSYCHOLOGY II

Name	Level of Mathematics Studied at School	Final Grade in Statistics	Average of Grades in Psychology II Excluding Statistics	Overall Grade in Psychology II
Alice	Primary School	Pass	High Distinction	Distinction
Norman	O' Levels Year 10 (equivalent)	Distinction	High Distinction	High Distinction
Sandra	O' Levels Year 10 (equivalent)	Distinction	High Distinction	High Distinction
Hettie	Primary School	Pass	Credit	Credit
Ernest	Year 10 (equivalent)	Pass	Distinction	Credit

5.2.2 The Students' Prior Conceptions Of Mathematics And Statistics

The students' reports of their initial expectations about Statistics were based on their prior beliefs about statistics. These, in turn, were generated by experiences which related to mathematics or statistics.

Alice conceived of mathematics as "a whole heap of figures". In the Attitudes Questionnaire (in Appendix B) completed for me during the Statistics bridging course before the first semester began (described in 4.4.3) she described herself as "bored and frustrated" by mathematics at primary school. She wrote that the experiences that led to this attitude were:

> bad teaching leading to a lack of comprehension and a mother who constantly said that she had no 'head for figures' so was not surprised that I didn't either.

Alice had worked as a caterer, so she would have had to do a certain amount of work with figures. I asked her in the interview whether that had given her any trouble. She replied as follows.

> No, but there were two of us doing it and we used to say: ‘Okay, you’ve got two hundred people, you allow a quarter pound of beef (in those days it was a quarter pound) per person.’ So you just multiplied that out, and rang the butcher. But that’s really simple stuff.

Alice evidently expected Statistics to be difficult and anticipated that she would have to manage on her own, rather than with the support she enjoyed in her real life problem solving. In addition, she thought of Statistics as a mysterious subject, having no connection to her experiences. She said that in her day statistics was not taught in school.

> It practically didn’t exist. It was something the government did. Every now and again they took a census. In those days there were no surveys about what brand of coffee you drank. I didn’t come up against it until I came here. When I first saw the word ‘statistics’ in the psychology book, I just blacked it out — I thought I’d worry about it when I came to it.

Norman stated that he had liked mathematics at school, on the whole, and in the bridging course Attitudes Questionnaire (Appendix B) reported that he was initially:

> reasonably looking forward to it (Statistics) though my priorities in life don’t include maths.

His conception of mathematics was shaped by a confident attitude to arithmetic and his interest in philosophy. He wrote

> There is maths which is simple numbers perhaps and maths which is concepts. Now I like maths which is numbers, I always add up numbers in my head in supermarkets, things like that. I like to play with numbers.

In the interview I pressed him for a definition of mathematics. He replied:

> It's a discipline or science concerned with numbers and quantification, perhaps. I do philosophy and I'm aware that maths is arguably being used to explain everything in the universe. I like the subject on that level — it's interesting, rational, abstract.

Hence, for Norman, studying Statistics held no terror. He was comfortable with mathematics at any level, whether concrete or abstract, and viewed it in terms of a game to challenge the mind.

Sandra, like Alice, separated formal or school mathematics from the mathematics she used in her everyday life. She replied to my interview question: "What is your concept of mathematics, your personal view?" as follows.

> It's simply working with numbers, it's putting quantities into numbers so that you can arrive at answers to particular problems.
>
> In my business I had to know how much money was coming in, how much money I was spending. That's really maths. That's what I think of as maths — everyday maths. I suppose I think of it as different levels of understanding. There's the everyday maths, which I can get by with very nicely, which is practical maths, and then there seems to be more esoteric areas, like calculus and so on, which I really don't know anything about at all.

Sandra reported in the Attitudes Questionnaire that at school she was bored and confused by mathematics. She attributed this to having gone to fourteen different schools, in different countries, where the educational systems did not match. Her perception of Statistics, as expressed in this questionnaire, was that it was "useless and dull". She initially appraised the Statistics lecture notes as "daunting" and described herself as "resistant" to learning Statistics.

Hettie, despite her business skills, was extremely anxious about studying Statistics. Looking back on her initial feelings about learning Statistics, she said this in the interview.

> I had accounting skills from running a business, so I was not completely innumerate. In second year, from day one, when we got

> the handout, I was panicked — by the algebraic equations, everything. This was what scientists, astrophysicists do, not what I could do.

These four students appeared to base their assumptions about the learning task facing them on their school experiences. Mathematical activities in school were considerably more distant in time than the mathematical problem solving they had addressed in the context of their work. However, they identified school mathematics as being the closest to the current task of learning Statistics. As indicated by the above quotes, Norman faced the challenge of Statistics with equanimity. The three female participants of this study, on the other hand, indicated that their competence in using mathematics in the setting of life skills was not translated into confidence in the environment of university education. Their comments show that they expected their university course to be an intimidating, mysterious and difficult subject, unrelated to the life skills they had developed. These observations on attitudes to mathematics in different settings complement the research of Lave (1988); Lave, Murtaugh & de la Rocha (1984); Rogoff & Gardner (1984) and Scribner (1984). They found that the setting of the mathematical task determined the success of the individuals using the mathematics. Adults in the context of practical or job-related tasks successfully developed a range of methods to solve problems, while similar problems in the arena of school arithmetic were tackled with considerably less success. From the theoretical perspective that I have developed, affective and cognitive aspects of learning are congruent with the contexts surrounding them and are inseparable from them.

Ernest could relate to mathematics only when he perceived it to be concrete and personally relevant. Asked for his beliefs about mathematics he replied as follows.

> I think it's awfully important because it is the only way we can measure something, consistently. That's what I like about mathematics.
>
> I did algebra (at school). I could never concentrate on that; geometry the same thing. Arithmetic I didn't mind at all, but the moment it became more abstract, the moment symbols entered the scene —

> without a teacher who could relate it to the practical usefulness of it, he lost me.

Ernest, unlike the other students, related Statistics to the statistical knowledge he applied in his everyday life, rather than to school mathematics.

> As a hobby for years, I have followed the races. I look at the percentages. I like the idea of comparing my percentages with those that the bookmaker has on the board, and at that level I have always dealt with statistics.

The students' prior beliefs about Statistics related to their experiences of mathematics and statistics. These were connected with two kinds of mathematical activities: mathematics or statistics as an activity in a practical setting, either work or recreation, and mathematics as an activity in the setting of formal education. While all the students experienced the former activity as useful and manageable, only Norman expressed a positive view of abstract mathematics or school mathematics.

As I outlined in section 2.4.4.2, Leont'ev's theory of activity poses three different levels of analysis (Leont'ev, 1981). The first level pertains to the setting — which defines the type of activity, for example work or education. For Alice, Hettie and Sandra, perceptions of the arena for learning Statistics related mainly to their schooling, separated from the practical settings in which they had experienced mathematics. The students identified the activity of learning Statistics, on the broadest level, by its institutional setting. Their prior conceptions of Statistics were that it would be like school mathematics. They also expected to experience problems learning it, notwithstanding their proven abilities in the vocational world. Norman and Ernest positioned themselves more favourably with respect to learning Statistics than did the three female students. They related the activity of learning Statistics to arenas in which they were challenged or had experienced statistics as relevant.

5.2.3 Goals And Actions: The Effect Of Context

In the activity framework all learning is regarded as goal directed (Leont'ev, 1978; 1981). The examples below illustrate that while all five students were set the same task of learning statistics as part of their psychology course, they produced differing goals in the process of participating in the activities. The features of these emergent goals were linked to the socioculturally defined contexts of their instruction.

Alice summed up Statistics as "incomprehensible but necessary". Initially, as she indicated on the Attitudes Questionnaire (Appendix B) her aims regarding Statistics were:

> to get a grip on it at least to a basic level of understanding.

At the end of the year, her goals concerning the Statistics she had studied related to her conception of it as a tool for research. In the interview she explained to me:

> I know I'm not going to be able to read numbers and understand experimental papers and I'm not going to be able to do my own work without it. I need it. I'll probably work on case histories as opposed to large samples. Ultimately I'm interested in memory area — brain damage, so I won't be working on large quantities of people. I might be working on, say, motor bike victims as opposed to people who have held their breath under water too long — they've suffered the same damage, but why is this so? That interests me enormously. It would be simple statistics that I'll be doing.

She hoped that when she wanted to apply it, she would be able to do so, but expressed concerns about the theoretical nature of the subject matter:

> I'm hoping that some of that stuff will be instantly recognisable. Now whether they make it more practically theoretical instead of simply theoretical, maybe that's going to help. I would rather be faced with a hundred coffee beans to play with than a lot of figures. I can't really explain it, but working it out on paper doesn't seem to me to have any relevance.

Before the academic year commenced, Norman evidently intended to make use of the Statistics he would be learning. He wrote in the Attitudes Questionnaire that his goals were:

> to learn enough statistics to become an effective psychologist.

During the year, however, he accorded priority to short term goals. His actions were directed to fulfil his evaluations of the institutional requirements:

> I have a very pragmatic approach to university, I give them what they want. Arguably if I could guarantee enough knowledge to get full marks in the tutorial test and the stats exam and know that I forgot it all completely afterwards, I'd almost go for that course, because that's what they want. I really do like knowledge for knowledge's sake, but my main motivation is to pass the course.

Sandra's account reflects a more far-reaching and personal perspective on her academic learning than that suggested by Norman's comments. Already working in a crisis clinic, she aimed to get the required qualifications in psychology, as she would get better pay and was:

> not comfortable doing crisis counselling as a non-professional — as much for my clients as for myself.

Her explanation of what she had gained so far by studying Psychology indicates personal development and an enhanced view of the world around her. She said in the interview:

> While a lot of course material is not relevant for counselling, a lot of the attitudes that you learn are important. A sense of professionalism in your approach, not a knee-jerk reaction to things, but sitting back and assessing it. The course teaches you to take many theories in and assess the different theories — not what is right and wrong but hold many different theories in mind at once. And sit back a bit more. People who haven't had that training ... they're more ... a knee jerk reaction.

Sandra achieved the identical high grade in Statistics to Norman but in contrast to his instrumental approach, her actions were characterised by a search for meaning:

> It's almost like two separate things in the Statistics course we've just done. You could have actually just got the steps and maybe not

> understood why you were doing it. I wanted to understand what I was doing.

For Hettie, Statistics lacked relevance to her vocational objectives. She said:

> Some statistics is essential but it's of very little use to people doing counselling — to me personally.

Hettie reported that she had put in three or four hours a week on Statistics and that it was too much time for the "bits" that she might require. She commented that:

> if there had been no assessment, I simply would not have put in the time or effort.

In the second semester Ernest wrote in the Statistics Course Survey (Appendix D) that he was more motivated to learn mathematics now than at school because he could see "its importance and application". He elaborated on this in the interview as follows:

> Related to the study of psychology, I could see very much the importance of it, because it relates to experimental results and what else can you do with them if you can't quantify them? So you need quantification, and maths is the only method we have, the only instrument we have for quantification.

His goals concerning the function of statistics in his future were instrumental:

> Apart from knowing that we need it as an instrument to measure things — beyond that my interest doesn't go. I would never become a statistician. If I ever work as a psychologist, I would either be a social psychologist, I would be a writer, or possibly even a clinical psychologist, dealing with people. And then whatever I needed in the way of statistics as an auxiliary to the work I was doing, I would of course make sure that I could control. But I wouldn't pursue it as an end in itself. Purely as a means to an end.

Goals are not produced by individuals in isolation but are influenced by social interactions, institutionalised practices and personal needs. In universities such as this one, a system has developed over time. Learning activities situated in universities are bound by the resources and conventions of this system, in particular, assessment. For some students, such as for Norman or Hettie, goals may be subordinated primarily to the requirements of assessment. For others, such as for Ernest and Alice, instrumental goals for using statistics in their future careers may not be congruent with the theoretical nature of academic learning. It seems that even students such as Sandra, whose goals in learning Statistics did serve educational objectives, may act in accord with these objectives in spite of, rather than because of, their perceptions of what is required in the university setting.

5.2.4 Approaches To Learning Statistics

In section 2.3.2.2, I outlined my perspective on surface and deep approaches to learning Statistics, drawing, in particular, on the work of Biggs (1987); Marton & Säljö (1976a, 1976b, 1984) and Marton, Watkins & Tang (1997). This perspective and research on learning in higher education (for example, Entwistle & Ramsden, 1983) suggests that in surface approaches to learning the student's attention and actions are centred on the task as an end in itself — on reproducing knowledge under assessment conditions. It suggests, too, that in deep approaches, the student focuses on meaning and understanding.

The approach adopted by a student is not fixed and unvarying but is constituted within a particular spatial and temporal context and content domain. The students' comments quoted below show that their approaches to learning Statistics were affected by personal factors, such as level of interest and perceived competence in learning Statistics, as well as by their prevailing perceptions of the context, particularly perceptions of time constraints and assessment demands.

Alice sought external clues to help her appraise the material:

> In the lectures I was sitting watching him go through the overheads of our notes and if he said: 'This is very important.', I would underline it and if he said: 'Don't worry about these pages.', then I wouldn't worry about those pages. I assumed the man knew what he was doing because he wrote the notes!

Alice wanted to understand and use the concepts. However, her difficulties with the mathematics and her perceptions of time constraints and assessment demands strongly inhibited her actions. She said:

> I thought if I could grasp the basic concepts I would be able to apply it to my exams — but I couldn't. There was something missing and I think it was my comprehension rather than their teaching. ... It's in a different language. I don't have a problem with languages — it must be the figures, Sue, I can only assume it's figures. I think the whole subject is really difficult! I just know I haven't understood it.
>
> I find that reading, say, a book on cognitive processes has logical progression and the material gets more and more in depth. Now Statistics probably does exactly the same thing, but I find that sort of book almost impossible to read, because of the things in chapter one which I stumble over. I'm not the sort of person who can skate over the top and think: 'Oh yes I won't worry about that!'. I have to get that straight before I can get to the next thing. And that holds me up.
>
> Given enough time, I can do all those things, but put me in a situation where I'm pressured. Ask me to write an essay about it and give me six weeks — no problem. Give me sixty minutes, and I have to do it step by step, so I run out of time.
>
> My essential problem is that I can't generalise from what I know to some other problem. In the 't- test' I did the working on the computer and came up with the right answer. I was totally thrilled with that. That was simple, but I had three weeks to work on that. You put me in an exam and give me five minutes to answer ten questions — and I'm history.

Alice wrote in the Statistics Course Survey (Appendix D) that the most difficult thing about learning Statistics was "coping with figures and symbols". This difficulty may have been ameliorated if she had interpreted Statistics in her functional language. However, she evidently defined the learning activity in terms of project management. In this setting mistakes are seen as costly (Wertsch, Minick & Arns, 1984). This perception prevented her from deciphering the mathematics. She did not dare convert it to more intelligible and transparent terms:

> I don't translate from maths terminology because one has to learn the terminology to put in for exams, so I may as well learn it right away, instead of translating to English and back. I'm terrified of doing that. I'd rather learn the technical terms first up, then make it simple, and then have to put it back into technical language.

Alice's study notes, written to summarise and revise Statistics, reflected a focus on the operations and algorithms rather than on a conceptual understanding of the content. She wrote in the Statistics Course Survey that her way of learning a mathematical topic was by "repetition". In the interview she reiterated this rote learning approach, reporting a perception that what was required was the memorising of details.

> You can't express yourself with this, you have to express what you are taught. The underlying concept is not such a problem but they don't ask you conceptual questions. If you started to be creative with it you'd run into the most appalling trouble — go off at a tangent. I'd never go outside what's in the book.

Hence Alice's actions were strongly constrained by her understanding of what was appropriate to do in the setting.

For Vygotsky and the activity theorists following him, the cultural, historical and social contexts for all activity are of primary importance. The comments quoted above reflect the relation between individual actions and the institutional arena surrounding them. On the level of more immediate social interactions, Alice's reports of her experiences, below, testify to Vygotsky's view that working in the "zone of proximal development", that is, mastery with the help of more capable others, precedes independent mastery (Vygotsky, 1978).

> I was working with Norman and Sandra — every Sunday night, almost the entire year. We went back over the previous week's lectures and tutorials, and went over it again and again and again, with the help of Sandra's husband who understands statistics. I can do all

> those (statistical) test things with the others around a table, we can get them right.

Norman reported adopting a surface approach to learning Statistics yet he achieved a high degree of success in the assessments:

> I just wanted to pass the course. Practice and repeat is the key. You have to have the basic understanding of when to apply the test, and that is almost formula. They are not looking to see if you critically appreciate because the test questions are very similar to the tutorial questions. Compare the test question to the tutorial question, if they're the same, apply the same formula.

Norman found the multiple-choice examinations harder than the class tests because of the speed with which each question had to be answered. For these, too, he relied on superficial clues, rather than understanding.

> To get away with doing it in one and a half minutes a question — anything less than knowing it really, really well — you were in trouble. I had to guess. A lot of multiple-choice questions are really tricks. If two of them are similar, then usually it's one of them.

Norman's comments, above, raise the question of what the assessments in Statistics actually measured.

Despite Norman's perceptions of the superficial quality of learning required in the context of academic learning, the social context provided by his working regularly with Sandra and Alice, resulted in a deeper approach.

> I invariably picked up some understanding anyway. Compared to Sandra and Alice. When I worked with the others as a group then I would try to do more of the understanding.

Hence institutional norms and social interactions mediated the relations among students' goals, their actions and the outcomes of those actions. In Norman's case the different approaches he adopted to learn Statistics and the quality of the ensuing knowledge as he reported it, were interwoven with the social settings surrounding his actions. As in Alice's case, engagement with the task of learning

Statistics, that is activity in Leont'ev's (1981) sense of the word, was associated with direct, interpersonal interaction. Together, Norman, Sandra (and her husband) and Alice created an interactive learning environment very different from the traditional lecture-tutorial settings in which they mostly studied Statistics and in this environment their activities were directed at attaining a conceptual understanding of Statistics.

Sandra's actions reflected her intention to achieve what Skemp (1976) calls a relational understanding of the subject matter. In Skemp's terms this means to understand mathematical concepts and topics in ways which inter-relate whole areas, are intrinsically motivated and serve as a basis of further and deep exploration of new topics and concepts. This construct accords with the view of deep approaches to learning that I have expressed so far. Sandra's notes summarising her study of Statistics indicated her intention to gain a relational understanding of Statistics. In these notes, she began each new section with an overview of what she saw as the purpose and ideas underlying that topic. Sandra reported her conception of learning mathematics by explaining that mathematics is:

> something that you learn by increments, by degree — a gradual accretion of knowledge.

Her concern that she would not be able to understand Statistics led Sandra to take action in a determined and methodical manner to overcome difficulties and fulfil her goal of understanding:

> I worked through my lecture notes at the same time as the lecturer did. I just wanted to get a broad brush stroke, a picture and then more detail with the 'tuts'. I went to three tutorials, one at the beginning of the week, one in the middle and one at the end. Each time it became a little clearer. By the third time I was feeling on top of it. And then I was coming here (to the Centre) twice a week as well. And I was working with Norman and Alice and my husband as well. We worked through examples for hours, our 'tut' sheets, to learn how typical these things are, to understand.

Like Alice, Sandra also did not have the confidence to pursue a broader study of Statistics than that presented in class:

> I stayed very much with my lecture notes, while with other subjects I did a lot more reading of texts, which would have given me more understanding.

Sandra, like Alice and Norman, indicated the importance of social interactions to her learning of Statistics. She wrote in the Statistics Course Survey, in second semester, that her way of learning Statistics was with assistance at the Mathematics Learning Centre getting:

> repeated explanation, where I feel free to ask questions, in a comfortable, supportive atmosphere; working through examples — talking about it.

It therefore appears that Sandra's initial grappling with the concepts of Statistics took place when she interacted with others — her teachers, colleagues or husband. This accords with the activity theorists' viewpoint that collective external activity precedes individual internal activity (Leont'ev, 1978; Vygotsky, 1962, 1978). Sandra's comment, below, shows that working collaboratively on Statistics helped her to overcome some of her anxiety:

> I didn't work a great deal on my own, although I did at the end. I had to go through it on my own — but I felt frightened working on my own.

Sandra reported an increase in confidence during the year. She noted in the Statistics Course Survey that:

> It is possible to learn stats successfully.

However, in this survey, she also expressed the view that she needed a better understanding of concepts and how to apply them in differing situations, adding:

> Also I need to learn to work faster.

This indicates her perception that a deep understanding of the concepts was necessary but not sufficient to perform well in assessments. This perception is well substantiated by empirical evidence (for example, Biggs, 1987). Sandra's perseverance led ultimately to a high grade in Statistics but in the examination she had to constantly fight against her own resistance.

> I had this constant overwhelming desire to put down my pen and say: 'I can't be bothered carrying on with this!'. It was very difficult.

Hettie wrote in the Statistics Course Survey that her main reaction to Statistics was "Panic!". So intimidated was she that she spent many lectures and tutorials in tears. She was torn between wanting to be accepted into the Honours stream, for which a minimum grade of a Credit in Psychology II was required, and her inability to come to terms with Statistics, an important part of the course for assessment purposes. In a conversation with me early in the year, she described graphically her feelings during Statistics lectures:

> When he put all that stuff on the board, I just froze. I was like the rat I'd been observing in the laboratory earlier on. I just curled up in my seat and froze in terror.

A shift in her attitude took place in the latter half of the first semester when we discussed her goals for Statistics. We decided that even if she only attained twenty percent for Statistics in the examinations, she could still meet her aim of getting a Credit for Psychology II, due to high grades, so far, in its other components. By lowering her goals to what she felt was realistic, she was able to make a fresh start. Freed from the paralysing anxiety she had experienced up to then, Hettie started to work through the notes and examples systematically, understanding it at her own level and in her own functional language. The outcome in first semester was a Credit for the multiple-choice exam and a pass in the tutorial quiz — well above the proposed twenty percent.

Hettie likened having someone explain statistics to her to having:

> someone describe a taste — not very meaningful.

The strategy she developed, with considerable pain, entailed acting systematically and energetically — engaging with the subject matter.

> Initially I wrote lots of notes which were not helpful because I did not understand what was going on, I just wrote down formulas. It took

> halfway through the semester before I systemised things and sat down — with your solutions and worked out the tutorial exercises. That is what overcame the phobia about it. For me it's not as though it can be explained. It's great to have a solution there. But you really need to take every little bit and break it down, every equation and break that down and understand what it is, and actually do it yourself.

The skills Hettie was trying to develop were related to understanding the underlying concepts rather than merely learning algorithms. She felt that in view of the use of computers time was better spent:

> on the concept of it, the meaning of it. Not the complicated mathematical process.
>
> I wonder if we need to learn how to manually work out things we are never manually going to work out. More in the tutorials than the lectures, they often present the concept of what it is, and give some kind of practical illustration of what it is rather than the mathematics of it. I think that's more useful in view of the use of computers.

Hettie realised that a very disciplined approach to studying Statistics paid off. In the Statistics Course Survey she wrote that her way of learning it was to get an overview of the concepts, then:

> to work through it myself — every step.

It seemed to me that she conceived of learning Statistics as struggling to land a large fish. She said:

> Stats more than anything else in psychology pays off from some attention, some time — serious time not just read about it. Reading about statistics doesn't do anything for me. I don't retain it. Read it — and five minutes later it's gone. It doesn't hook in to anything that is in your mind. The only thing it will hook into is the tutorial exercise you did last week. When you've actually done it. Its not a thing that's not graspable — it's just a thing I had to grapple with and put in some time.

In this description of how she grappled with learning Statistics, Hettie illustrates the essence of what Leont'ev (1981) means by activity — effortful and purposeful behaviour, which included overt actions (doing problems) and cognitive actions — reflection, making connections.

In the Statistics Course Survey, Ernest reported that, unlike Hettie, he did:

> appear to absorb more through <u>reading</u>.

He described an holistic way of learning Statistics, writing that he preferred:

> a clear handbook to explain the issues involved,

and, in contrast to Alice,

> plain language presentations (before going) into symbolic formulation.

Ernest expressed a strong desire to adopt a deep approach to learning. Despite this, his actions were constrained by his perceptions of the pressures of the academic setting. His comments bear out observations by Entwistle & Ramsden (1983, p. 116) that students can perceive a conflict between grades and learning and that they:

> speak of using strategies to get good grades at the expense of understanding the material.

In the interview Ernest explained his perceptions as follows:

> I must admit, because of the time factor involved, I always had in mind that interest might come later, but now you've got to get things ready for the tutorial test and later the exam. I would have avoided pursuing it beyond the immediate requirements out of fear that it would possibly confuse me and overload the circuits. They go through a tremendous load. The content is so that you can't deal with all that content in a qualitative sense. You can only do it in a quantitative sense.
>
> I'm interested in learning theory, we did it as part of our psychology course, and to me a fascinating person was Betty. She always claimed that she was completely helpless, that she didn't understand it (Statistics). And we more or less agreed on difficulties before the lectures. And yet she did extremely well in Statistics, got a High Distinction. So I thought: 'Well, I seem to have the same problem

> with the material, and yet she manages to overcome this, she gets good results and I don't. Why is that?'.
>
> And I can only think of an answer that it's a matter of how our minds work. I tend to make a synthesis of things, I want to understand them. I'm a deep thinker, put it that way, while other people simply seem to work at a more superficial level, and take it in and remember it and reproduce it. And I can't do that, you see. To me it first has to be digested. I am an internaliser and I feel that Betty and others like her are externalisers who therefore have a greater facility of doing it quicker, while I take much longer. But I feel that I get a deeper understanding.
>
> For Statistics, I think maybe a lot of people just have the facility of learning that quickly. They don't feel the need like I do to relate it and to internalise it and therefore their brain obviously has a limited function which it can perform quicker, than if you want to look at all the circuits — as to where its leading. Look at the overall picture — that can slow you down. So that's my theory.

Ernest's last comment attests to an all too often reported paradox that:

> institutions often appear to discourage the very things that, officially, they are committed to foster (Biggs, 1991, p. 226).

In particular, for students who are not comfortable with, or facile in, assessment driven learning, it appears that perceptions of the university educational system can obstruct actions directed towards high quality learning.

5.2.5 The Students' Self Regulations And Evaluations Of Learning Statistics

The view that activity is goal driven is central to Leont'ev's theory (Leont'ev, 1978, 1981). The connection between a student's goals and her actions is self regulation. It is on this account that recognising a student's interpretation and evaluation of the learning task is important to understanding that student's activities. Self regulation of thought is explained by Semenov (1978, p. 5) as being on two planes. As described earlier (p. 32) the reflective or "intellectual plane of thought" designates how the subject monitors and controls the ongoing cognitive activity, while the “personal plane of thought” refers to the degree to which the problem solver evaluates success in personal terms. In Semenov’s (1978, p. 5) words:

> a subject does not simply solve a problem: the process is, at the same time, an act of self realization.

Hence, these metacognitive processes of monitoring and evaluation are paramount in defining the activity.

Alice wrote in the Statistics Course Survey in the second semester that she had achieved:

> a gradual increase in confidence and some glimmerings of understanding.

However, at the end of the year she expressed frustration at her inability to achieve her goals:

> I don’t like having this area of weakness in the overall course, when the other areas are so strong. It annoys me that I can’t grasp it, I’m an intelligent person — why can’t I get it?

Alice’s evaluation of her performance was evidently based on her grades, as in a different setting, where no external authority was judging her, she demonstrated confidence in her ability to understand statistics:

> When I’m reading a newspaper or magazine, now, I don’t skip the statistics, I can actually read it and understand it. I don’t just accept what someone writes — I question it. Someone phoned to do a survey. I asked him how many people he intended to survey. He was taken aback and asked why. I said: ‘If you are going to survey ten people I’m not going to bother answering your questions. It’s going to be nonsense!’.

This account was in sharp contrast to her response at the beginning of the year to a question in the Attitudes Questionnaire (Appendix B) on reactions to everyday situations involving mathematics, such as reading surveys and statistics in magazines and newspapers. At that time she had written:

> don’t read stats in newspapers!

Hence Alice's actions relating to her evaluation of her own statistical competence depended on the context in which she was making those evaluations.

Norman's plans for his future were in the academic field. His goals were:

> to be an academic psychologist, do a Phd, do counselling as well, or a counselling psychologist.

He reported in the Statistics Course Survey (Appendix D) that he found it difficult:

> getting a grip on concepts that I had never thought about in everyday life.

I asked him in the interview whether he would continue to study statistics in third year, if he had the choice. His reply indicated that the challenge of overcoming his difficulties seemed to mediate against purely instrumental goals in learning statistics:

> I don't know. Its not clear cut. I would lean to not doing it, but wouldn't be too certain about the idea. Even if I knew I'd never need it. It's one of those things that when you could do it it's great. I really liked it when the answers come out.
>
> If my mother, instead of a psychologist, had been a mathematician, I'd be into math. I do quite like abstract ideas. Similar sort of learning — the curiosity to know and explain something via numbers and equations. I can see if that was a strong feeling with me I would find it fascinating. Read a paper by someone who tried to mathematise thinking — pages and pages of equations to explain how human beings think. It sank without a trace but I could see an interest on those sort of levels. If I had an interest not in people but in numbers it would be fun manipulating equations. Same learning style, I'd think about it more often.

Sandra felt that her learning activity had resulted in personal development:

> By the end of the year I thought, it doesn't really matter how I go in this exam. I'm not going to let the exam mark dictate to me my knowledge. Because I knew I had a better grasp at the end of the year and I really felt that if I was doing experimental work I could work out what to do with my stats.

> It felt very good, it felt a lot like growing up. All my life it felt like I had this dark secret:— that I felt really stupid about this area. I'd cover it up so no-one would know. It really felt like growing up.

Hettie's gradual awareness that she was capable of learning Statistics produced a sense of achievement:

> I wouldn't choose to go on with statistics, because it's not an area where I get very good marks, and in the end that does matter. It's one of those things that when you get a bit of a handle on the fundamentals, then you've got something to build on — so it doesn't intimidate me. In fact I get this strange sort of satisfaction out of doing the tutorial exercises now. It's like a puzzle. While I'm actually doing it, I quite enjoy doing it. It really bolstered my self confidence. You might recall — I used to weep. I found it very stressful and I was absolutely certain that this was beyond my capabilities.
>
> It disciplines you in a particular way I think, because it's a field of inquiry not connected to your normal life; it exercises a part of my mind that I normally would not have. And it has increased my confidence quite a lot.

Hettie had thus developed her metaknowledge about the process of learning Statistics to include an awareness of her capabilities and a sense of how to allocate her cognitive resources.

Ernest acted on his need to understand, but expressed the idea of a conflict between university education in practice and deep approach to learning:

> To me its very important how a subject is presented. It's always the case that the degree you can identify with it is the degree it arouses your interest. It's really intellectual curiosity because even during the holiday, when most students would have thrown their books in one corner, I have been pursuing those things that we simply didn't have time to pursue during the year.
>
> I really found that I was never quite happy with Statistics. I felt that if I had been in charge of giving that course I would have approached it

> in a different manner. I would have made it more interesting, I would have related all those different (statistical) tests to what they were meant to do. The notes immediately went into formulae, rather than what this test does.
>
> Once I see the logic of it, then I have no problems with it. But if they don't deal with that logical function then immediately I start questioning the need for it. Like at school, when the guy was droning on about algebra, even more so for geometry, I said to myself: 'I don't think I'll ever need that in my life.' — and I lose interest.
>
> All they can possibly say in defence of their way of teaching is that the intellectually curious student may still find it a useful base to depart from and to develop, evolve from. What they overlook is that a lot of the people who are not so interested, who do not have this native interest in the subject — they will not get it because of the way they teach. If they taught it in a more interesting way — if they taught people to think about it, rather than to repeat it ... . We do nothing to arouse this intellectual interest apart from making them exam smart and certainly with young students, all they talk about is what is needed for the exam.

While the rhetoric surrounding teaching at university emphasises making resources available to learners, it is the student's metacognitive awareness that plays a central role in determining how these resources are used. On the "reflective plane" (Semenov, 1978) self regulation provides the links between what is to be learned and how it is learned. Norman, for example, regulated his approach according to whether he was carrying out his goal of just passing the course or of helping his friends make sense of the lecture notes. On the "personal plane" of regulation (Semenov, 1978) the resources available to students are evaluated in terms of personal interests, perceptions of self-capabilities and attitudes. Ernest's self judgement of his performance was based on his own objectives as well as his appraisal of the instructor's requirements. In his own words:

> I want my questions to be answered. When I was the age eighteen, nineteen, twenty, I wouldn't have worried about the deeper significance of it either.

In quantitative terms the outcomes of learning Statistics for the five students can be assessed by their grades: simply that three passed and two obtained distinctions. As the above comments show, however, it is students' goals in their sociocultural contexts that provide the criteria against which students qualitatively evaluate the outcomes of their learning. Sandra's satisfaction at her personal development or "growing up", Hettie's increase in confidence and Ernest's disappointment at what he perceived as a requirement for students to repeat suitable portions of the course, rather than to think about it, are some of the qualitative evaluations that emerged from the data.

Marx (quoted by Davydov, 1990, p. 332) summarises the product of learning as follows:

> Knowledge is the result of the subject's active intervention in the process of changing reality.

The mature participants of this study were aware of the meaning of their own experiences and environment and this awareness was at the core of their learning.

5.3 CONCLUSION

5.3.1 Summary In Terms Of Research Questions

Wertsch proposes (in an editorial, in Semenov, 1978 p. 3) that:

> the human problem-solver is viewed as bringing a complex system to a task situation and that this system plays just as important a role in the resulting outcome as does the information from the environment.

The data reported in Study One provide evidence of this complex system.

- The students' conceptions of mathematics or statistics differentiated practical, everyday mathematics and statistics from the more abstract mathematics they associated with academic learning. Based on their experiences, most of them reported perceptions of "life statistics" as useful and manageable, while "school mathematics" appeared to all but Norman as difficult, uninteresting and irrelevant. These conceptions identify two different sorts of statistical knowledge. There is knowledge as a tool for use in real life — what Perkins (1986) calls "knowledge as design" or knowledge as performance in assessments.

- The actions that the students took in order to learn Statistics related to their immediate goals, mediated by their perceptions of the institutional setting. The goals reported by the five students reflect quite different social perspectives and values. For example, Norman regarded learning statistics as a commercial transaction in which the aim is to earn the marks. His understanding of learning in the university context was that it is driven by assessment, and that other motivations take second place to this. Sandra, on the other hand, reported the intention to understand the underlying concepts of Statistics whether or not this was rewarded in the examinations. For Alice, giving priority to goals relating to the quantitative outcome of learning Statistics counteracted understanding and constrained her use of personal resources.

- The students adopted diverse approaches to learning Statistics congruent with their interpretations of learning Statistics, for example, perceptions of the demands placed upon them. These show that intentions and strategies are often compromised by academic practices. Alice, for example, emphasised points in her lecture notes as being important on a basis which was independent of any awareness of their meaning to her. Norman used techniques unrelated to an understanding of the material to solve problems under examination conditions and Ernest believed that a deep approach to learning disadvantaged him in assessments. The students' intentions and strategies with respect to learning Statistics unfolded over time, in some cases resulting in confidence, an increase in metacognitive knowledge and a sense of achievement.

- The excerpts quoted in this study suggest that knowing Statistics includes perceptions of its value. Cultural values, or what Leont'ev (1978) calls "meanings" are not simply assimilated by an individual, but are appropriated (Rogoff, 1995) as "personal sense", that is, monitored in terms of the individual's own value system (Leont'ev, 1978, p. 92). Shared interactions trigger differing insights and feelings in participants. In this study the students' metacognitive processes of monitoring and evaluation were shown to be critical in defining their activities. To Sandra, an exceptional student, evaluation was in terms of the quality of learning and self development she felt she had achieved, enabling her to broaden her outlook and gain insights on the particular facts and skills which she had learned.

In social cognitive theory, evaluative processes are referred to as self regulation, by which students observe, judge and react to their perceived progress towards goal attainment (Bandura, 1986). Consistent with this view, and drawing on the notions of Vygotsky (1978) and Leont'ev (1978) my findings in this study show that monitoring processes, which have their roots in the social world, mediate students' experiences, guiding their thinking and their overt actions. They are the means by which students fulfil their goals and, in some cases, enable their self realisations.

The activity perspective on learning Statistics highlights that, rather than being an external body of knowledge existing independently of the learner, the subject matter is organised within personal and contextual constraints. The mature, adult students who participated in this study had a rich history of experiences and a strong awareness of their own beliefs, expectations, needs and goals. My findings show that both personal components and contextual factors were integral to how these students learned Statistics.

5.3.2 Questions Raised By Study One

The results of Study One demonstrate a range of orientations to learning Statistics and of learning outcomes. This study raises questions for further investigation. How do mainstream Psychology II students feel about learning Statistics? What are their conceptions of the subject matter? What are the approaches to learning Statistics that they report? What are the relationship among these and other variables such as performance in examinations? What are the implications for teaching students who study statistics at university as a service course? These questions form the basis for the investigation undertaken in Study Two.

CHAPTER SIX

RESULTS OF STUDY TWO: UNDERSTANDING UNIVERSITY STUDENTS LEARNING STATISTICS AS A SERVICE COURSE TO PSYCHOLOGY

PART ONE — DESCRIBING THE VARIABLES

6.1 INTRODUCTION

Previous research on students' learning of mathematics or statistics at university shows that students' conceptions of the subject matter and approaches to learning it are crucial in determining the quality of their knowledge (Crawford, Gordon, Nicholas & Prosser, 1994a; Gordon, 1995b; Williams 1993). The theoretical framework outlined in Chapter Two and Chapter Three and the findings of Study One highlight the need to address explicitly the relationships among students' perceptions, actions and evaluations and the learning contexts which these both reflect and shape. In Study Two, I enhance an understanding of student learning within the subject field, statistics, by analysing facets of students' orientations to learning Statistics — their feelings about learning it, conceptions of Statistics and approaches to learning it. I further explicate the relationships, developed in Study One, among orientations to learning Statistics, actions, quality of knowledge and the surrounding social, institutional and cultural contexts.

6.1.1 Chapter Preview

In section 6.1.2, below, I reproduce the five sub-principal research questions of Study Two. These will be addressed in this chapter. Section 6.2 relates some information about the participants of Study Two — the distributions of variables such as gender, age, fluency in English as self reported and prior level of mathematics and statistics studied. The students' intentions with respect to the study of Psychology and their expected final grades in both Psychology II and Statistics are also summarised.

The next section (6.3) concerns the ways the students felt about studying Statistics as a compulsory component of Psychology II. I describe the students' survey responses expressing whether or not they were learning Statistics willingly and the reasons they reported for their willingness or reluctance. These were divided into personal reasons or intrinsic reasons and reasons associated with external factors, such as the perceived usefulness of Statistics to future careers or organisational factors. Striking differences were found between the reasons given by students willing to study Statistics and those given by the majority who expressed reluctance.

In section 6.4, I report on the structure of the qualitative variation of conceptions of Statistics, using a phenomenographic analysis of students' written statements. In this section I describe the categories of conceptions identified by the phenomenographic analysis and their distribution, including a breakdown of the frequencies by gender and reported willingness to learn Statistics. A table summarising the categories, view of knowledge indicated by that category and representative response concludes the section.

An analysis of the Approaches to Learning Statistics Questionnaire is presented in section 6.5. I evaluate the internal consistency of the two scales of the questionnaire — the Deep Approaches to Learning Statistics Scale (referred to from this point as the "Deep Scale") and the Surface Approaches to Learning Statistics Scale ("Surface Scale") and discuss what they denote. I provide the statistics about students' scores on these scales — and discuss how these scores relate to gender and whether or not students would have chosen to study Statistics.

The final set of variables described in this chapter are those describing performance on assessments (section 6.6). Descriptive statistics are reported for students' marks in Statistics and in Psychology II. All marks presented are raw marks, that is, I present them as they were before any faculty scaling or adjustments were made. I outline the relationships between students' expected grades in Statistics and Psychology II, as self reported on the survey, and the final marks they actually attained. I compare the performances of males with females and of those willing to study Statistics with those expressing reluctance to do so.

Interviews with two students are reported in section 6.7 to add to the insights provided by the analysis of the surveys and to triangulate the findings.

The chapter concludes with a summary of the findings described so far in Study Two.

6.1.2 Research Questions Addressed in Chapter Six

In this chapter I present the first part of my results by describing the variables of major interest to Study Two. I report on my findings relating to the principal research question with particular attention to the first five sub-principal questions. These are reproduced below for convenience.

The principal research question of Study Two is:

> **What are students' feelings about learning Statistics, conceptions of it and approaches to learning it and what are the relationships of these factors to each other and to other variables including gender and performance on assessment tasks?**

The first five sub-principal research questions are as follows:

1) What are the demographic or individual differences for the students participating in Study Two as indicated by the following variables: gender; age; fluency in English; degree for which enrolled; prior level of mathematics studied; prior level of statistics studied; intentions as to future study of Psychology and expected performance in Statistics and Psychology II.

2) What are the affective factors reported in response to the survey question:

   Would you study statistics if it were not a requirement of your psychology course?

   Please give reasons for your answer.

3) What categories of conceptions of Statistics emerge from students' written responses to the three open-ended questions in the survey, including the question:

What in your opinion is this statistics course about?

Please explain as fully as possible.

4) What are the students' approaches to learning Statistics as indicated by a questionnaire — the Approaches to Learning Statistics Questionnaire (ALSQ)?

5) What are the assessment results of the surveyed students?

Note: The survey is reproduced in Appendix F.

6.2 DEMOGRAPHIC AND INDIVIDUAL DIFFERENCE DATA

In this section I describe some features of the participants of Study Two. The highlights of this data are presented in Table 6.2.1 (p. 161). This table is followed by a description of students' intentions with respect to their ongoing study of Psychology and their expected grades in Statistics and Psychology II as reported in their surveys.

The survey was completed by 279 Psychology II students. Almost three quarters (203) were female, an unusual gender balance for an empirical study concerning the learning of a mathematical subject. Most of the students (184 students, 66%) were either 19 years old (133 students, 48%) or 20 years old (51 students, 18%) though a sizeable minority (46 students, 16.5%) was at least 25 years in age.

As would be expected for students studying psychology, the surveyed students reported themselves to be fluent in English. In answer to the survey question:

How fluent do you consider yourself in English?

only three students circled the alternative *not fluent*. Twenty five students (9%) considered themselves *fairly fluent*, while 250 students (90% of those surveyed) reported that they were *very fluent*. Gender proportions here were similar to the overall proportions.

The majority of the students (183 students, 66%) were studying Psychology for an Arts degree, with the bulk of the rest made up by the 48 students enrolled for Science degrees (17%); 19 Economics students (7%); 15 Education students (5%).

The prior level of mathematics studied by the surveyed students was higher than is often assumed for Psychology students. Almost one quarter of those surveyed (68 students) had studied mathematics at university, most of these having completed a first year mathematics subject at The University of Sydney. Of the rest, almost all had studied mathematics for the Higher School Certificate (HSC) of New South Wales at one of the following levels: 2 Unit Mathematics in Society, 2 Unit Mathematics, 3 Unit Mathematics or 4 Unit Mathematics. All except the first of these school units, which is not considered a prerequisite for any university subject, include the study of Calculus. Indeed, 163 students (over 58% of the participants) who had not studied mathematics beyond school level, had written the HSC at one of the three highest levels offered in mathematics. Thirty four percent of the surveyed students had studied 2 Unit Mathematics, 22% had taken 3 Unit mathematics and 3% the very demanding and challenging 4 Unit mathematics, the highest level of mathematics available for study at school in New South Wales. Twenty six students (9%) had not taken mathematics for the HSC. These were almost all older students, with 22 of them being at least 25 years old.

All the surveyed students had studied a brief (about 5 weeks) introductory course in statistics in first year Psychology. Statistics was also a component of all first year mathematics subjects at The University of Sydney. In addition, 79 students (28%) had studied statistics as a tertiary level subject in its own right, prior to the current study. For example, 30 (11%) of the surveyed students had taken General Statistical Methods, a first year elective subject for Arts students at The University of Sydney advocated for the study of Psychology or Economics. This subject could not be taken by mathematics students. Elementary descriptive statistics and some aspects of probability theory are currently taught at secondary school in New South Wales.

Table 6.2.1, below, summarises the above data by showing the (rounded) percentages of the participants in the modal categories, as well as in some other categories I wish to highlight. Percentages in the final column are out of 279, the number of students surveyed.

TABLE 6.2.1

SUMMARY OF DEMOGRAPHIC DATA FOR PARTICIPANTS IN STUDY TWO.

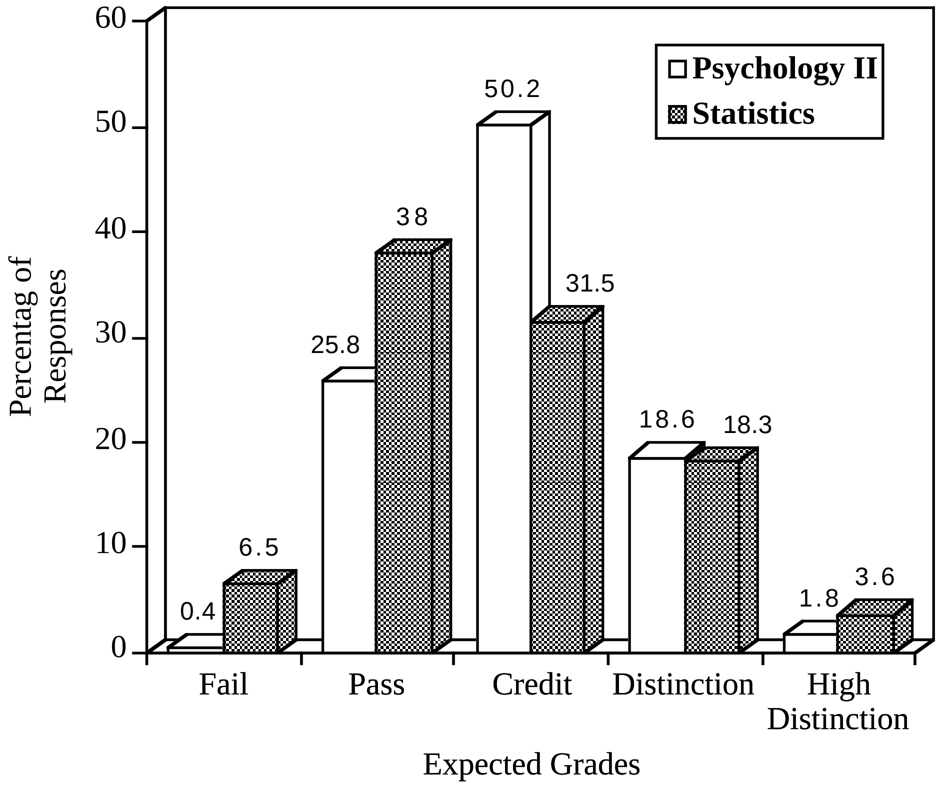
Category (Valid N)		%
Gender (N=278)	FEMALES	73
Age (N=277)	19 or 20 YEARS OLD 25 YEARS OLD OR OVER	66 16.5
English Fluency (N=278)	VERY FLUENT	90
Degree (N=278)	ARTS SCIENCE	66 17
Highest Level of Mathematics Studied Previously (N=273)	LESS THAN YEAR 12 2 UNIT MATHEMATICS 3 UNIT MATHEMATICS UNIVERSITY MATHEMATICS	9 34 22 24
Statistics Studied (N=279)	GENERAL STATISTICAL METHODS	11

Interestingly, 57% of the students (159) expressed an intention to study Psychology at the postgraduate level (Honours: 32%, Masters: 20% and PhD: 5%) and only 7% (19) of the participants reported that they intended terminating their study of Psychology after completing second year.

The students' expectations of their grades in Psychology II and in Statistics are shown below in Figure 6.2.1. These distributions show that most of the students were very optimistic about their assessment outcomes in Psychology II, with over 70% of the participants expecting to get at least a Credit in Psychology II. On the whole, the students were considerably less hopeful about their outcomes in Statistics, although more students (10 students, 3.6%) expected to attain High Distinctions for Statistics than for Psychology II (5 students, 1.8%).

FIGURE 6.2.1

DISTRIBUTION OF STUDENTS' EXPECTED FINAL GRADES IN PSYCHOLOGY II AND STATISTICS



Note: Nine students (3.2%) did not report their expected grades in Psychology II and 6 students (2.2%) did not give their expected grade for Statistics.

In summary, most of the participants of Study Two anticipated further study in Psychology and many expected to do well in Psychology II. Their performances in Statistics, an important component of Psychology II (counting 25% of the final mark) would have a significant impact on whether these students fulfilled their plans.

6.3 WILLINGNESS TO LEARN STATISTICS

This section of the chapter reports on the students' appraisals of studying Statistics as elicited by the first open-ended survey question:

> *Would you study statistics if it were not a requirement of your psychology course?*
>
> *Please give reasons for your answer.*

The verdict of the surveyed students on whether they would have studied Statistics, given the choice, was overwhelmingly negative with 73% (204 of the 279 students) responding "No" to the question, compared to 25% (71 students) who responded "Yes" (4 responses were missing). Interestingly, this proportion was identical to that found in my pilot study (Gordon, 1995b) when a sample of 52 Psychology II students at the same institution three years previously, with a different lecturer, were asked the same question. Although a somewhat bigger proportion of males than females responded "Yes" to this question (29% of the males, compared to 24% of the females) gender differences were not statistically significant.

These findings complement previous research showing strong negative associations between participation in mathematics or science courses and social interests. Ainley, Robinson, Harvey-Beavis, Elsworth and Fleming (1994) investigated the subject choice of Australian students in the final two years of school. They found that those who reported a high level of social interest, defined as interest in nurturing or helping others, had low interest and participation in mathematics and the physical science subjects. This is also consistent with Holland's theory of relationships between interest types, whereby subjects associated with technical competence or "investigative" activities such as mathematics and science, are unlikely to attract or appeal to students with high social interests (Holland, 1985, p. 30).

6.3.1 Students' Reasons For Their Willingness Or Reluctance To Study Statistics

I carried out a content analysis of the students' responses to the second part of the open-ended question shown above — their reasons. The responses were found to fall into a positive (i.e. favourable towards Statistics) or negative (unfavourable) dichotomy within the following classifications:

PERSONAL EVALUATION:	Evaluations in terms of personal considerations such as interest, affect and confidence;
PRACTICAL ASSESSMENT:	Appraisals based on factors such as perceptions of Statistics as necessary for psychology, useful or not useful for the study of other subjects or further study, societal applications or in terms of organisational factors such as workload.
BELIEFS:	Beliefs about the perceived difficulty of the subject, reasons concerning statistics as a basis of psychology as a science and other beliefs about statistical knowledge.

Most of the responses were categorised in the first two classes (see Table 6.3.1, below). These two categories distinguish students' reflections on self realisation from their perceptions of culturally valued factors. This qualitative difference may be interpreted in terms of Leont'ev's (1978, p. 92) differentiation between "personal sense", which has individual, psychological significance, and his notion of "meaning" as collective or socially endorsed. The category of PERSONAL EVALUATION also resonates with Semenov's (1978) exposition of the personal aspects of problem solving. According to Semenov (1978, p. 11) these depend:

> on the positions and roles assumed by the individual in the process, which, in turn, determine the value and meaning attached by the subject to the cognitive acts he performs.

Each of the three classifications: PERSONAL EVALUATION, PRACTICAL ASSESSMENT and BELIEFS separated into a number of categories. Table 6.3.1, below, summarises the distribution of the reasons, as classified. The categories are listed in descending order of frequency within the three classes listed. As will be clarified in the next section (6.3.2) many students gave a number of reasons which fall into different categories, resulting in more responses than students. However, within each category, the number of responses is also the number of students. I have indicated the mode for each category in bold font. Percentages are out of 279 (the number of students surveyed) and are rounded to whole numbers, except where percentages are less than 1%.

As can be seen, the most frequently cited reasons were negative and personal, with 29% of the students reporting Statistics as boring or tedious (INTEREST). The category with the highest positive frequency was NECESSARY FOR PSYCHOLOGY with 16% of the students giving a positive response in this category. These responses indicated that Statistics was integral to psychology as a discipline without specifying why this was so. They were categorised separately to responses referring to the specified usefulness of Statistics, for example, in society (GENERAL USEFULNESS) or for a career.

Gender proportions for favourable and unfavourable responses were similar within each of the categories (no statistically significant differences found).

TABLE 6.3.1

FREQUENCIES OF REASONS REPORTED BY THE STUDENTS FOR WILLINGNESS OR RELUCTANCE TO STUDY STATISTICS

PERSONAL

Category	Number of Favourable Responses	Number of Unfavourable Responses	Total
INTEREST	5 (2%)	**80 (29%)**	85
AFFECT	13 (5%)	**37 (13%)**	50
PERSONAL RELEVANCE	0	**21 (8%)**	21
CONFIDENCE	0	**20 (7%)**	20
MATHEMATICAL ORIENTATION	2 (0.7%)	**13 (5%)**	15
SUFFICIENT KNOWLEDGE	0	**12 (4%)**	12
MISCELLANEOUS (Personal)	2 (0.7%)	**3 (1%)**	5
LACK BACKGROUND	0	**2 (0.7%)**	2
NO ESSAYS	1 (0.4%)	**2 (0.7%)**	3

PRACTICAL

Category	Number of Favourable Responses	Number of Unfavourable Responses	Total
NECESSARY FOR PSYCHOLOGY	**46 (16%)**	8 (3%)	54
GENERAL USEFULNESS	**19 (7%)**	1 (0.4%)	20
OTHER/FURTHER STUDY	**14 (5%)**	4 (1%)	18
RELEVANCE TO CAREER	6 (2%)	**7 (3%)**	13
NEEDED FOR RESEARCH	**12 (4%)**	0	12
TIME REQUIRED	0	**4 (1%)**	4
WORKLOAD	0	**3 (1%)**	3
EFFECT ON GRADES	0	**3 (1%)**	3

BELIEFS

Category	Number of Favourable Responses	Number of Unfavourable Responses	Total
DIFFICULTY	2 (0.7%)	**40 (14%)**	42
PSYCHOLOGY AS SCIENCE	1 (0.4%)	**3 (1%)**	4
OTHER BELIEFS	2 (0.7%)	**4 (1%)**	6
Insufficient information given			22 (8%)

6.3.2 Examples Of Students' Responses

Excerpts from the students' responses are shown in Table 6.3.2, below. These are presented for the categories where the total frequencies were 20 or higher. A full description of all the categories listed in Table 6.3.1, above, as well as excerpts from each of these categories, is presented in Appendix J.

The excerpts in Table 6.3.2 are divided into responses favouring the learning of Statistics and those indicating negative appraisals. The numbers preceding the excerpts refer to the code on the survey quoted. These excerpts are usually only portions of students' responses. As I mentioned earlier, most students gave reasons which fell into more than one category. For example, consider the two survey responses reproduced below. The first student's response to Question 1 (survey code 145) was scored as positive in the category NECESSARY FOR PSYCHOLOGY and negative in the category INTEREST. The second example (code 206) had positive scores in two categories: INTEREST and GENERAL USEFULNESS.

145: *No because although I see it is necessary for psychology I find it boring and tedious.*

206: *Yes. It's interesting and very useful in everyday's life.*

TABLE 6.3.2
REPRESENTATIVE EXCERPTS FROM STUDENTS' RESPONSES TO FIRST OPEN-ENDED SURVEY QUESTION

PERSONAL EVALUATION

Category	Examples: Favourable Responses	Examples: Unfavourable Responses
INTEREST	5 responses (2%)	80 responses (29%)
Excerpts	206: *It's interesting*	106: *cause I generally find it dull, boring and tedious*
AFFECT	13 responses (5%)	37 responses (13%)
Excerpts	245: *I sort of dig numbers*	234: *I dislike maths intensely*
PERSONAL RELEVANCE	0 responses	21 responses (8%)
Excerpts	—	162: *No, it is irrelevant to my life*
CONFIDENCE	0 responses	20 responses (7%)
Excerpts	—	143: *Maths of any sort immediately makes me cringe*

PRACTICAL ASSESSMENT

Category	Examples: Favourable Responses	Examples: Unfavourable Responses
NECESSARY FOR PSYCHOLOGY	46 responses (16%)	8 responses (3%)
Excerpts	228: *It is necessary in the study of psychology*	57: *I am not sure what relationship there is between statistics and psychology*
GENERAL USEFULNESS	19 responses (7%)	1 response (0.4%)
Excerpts	18: *statistics are used throughout our society i.e. newspaper reports & it is important to have an understanding of the way in which information is gathered, processed & manipulated*	115: *No, it is not a practical subject*

BELIEFS

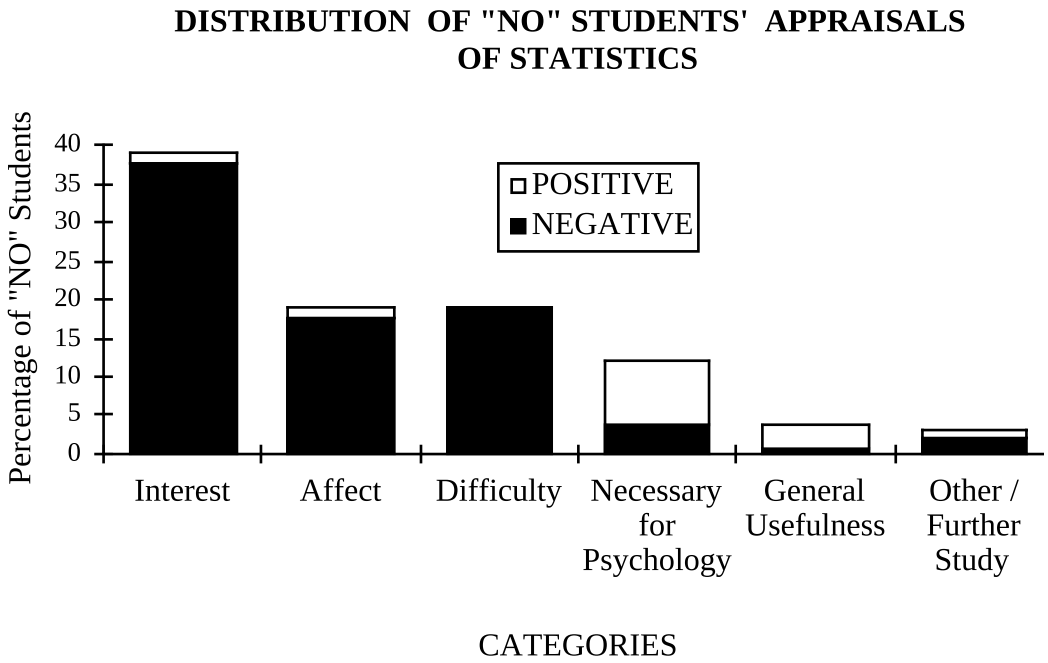
Category	Examples: Favourable Responses	Examples: Unfavourable Responses
DIFFICULTY	2 responses (0.7%)	40 responses (14%)
Excerpts	2: *It's not too hard*	209: *it is difficult to master*

6.3.3 Distribution Of Responses According To Willingness Or Reluctance To Study Statistics

Different reasons were given by students who responded that they would not study Statistics, given a choice ("NO" students) and those who apparently would have studied Statistics, even if it had not been compulsory to do so ("YES" students). The most dramatic differences between these two groups can be seen in Figure 6.3.1, below.

FIGURE 6.3.1

DISTRIBUTIONS OF RESPONSES FOR "NO" AND "YES" STUDENTS IN HIGH FREQUENCY CATEGORIES



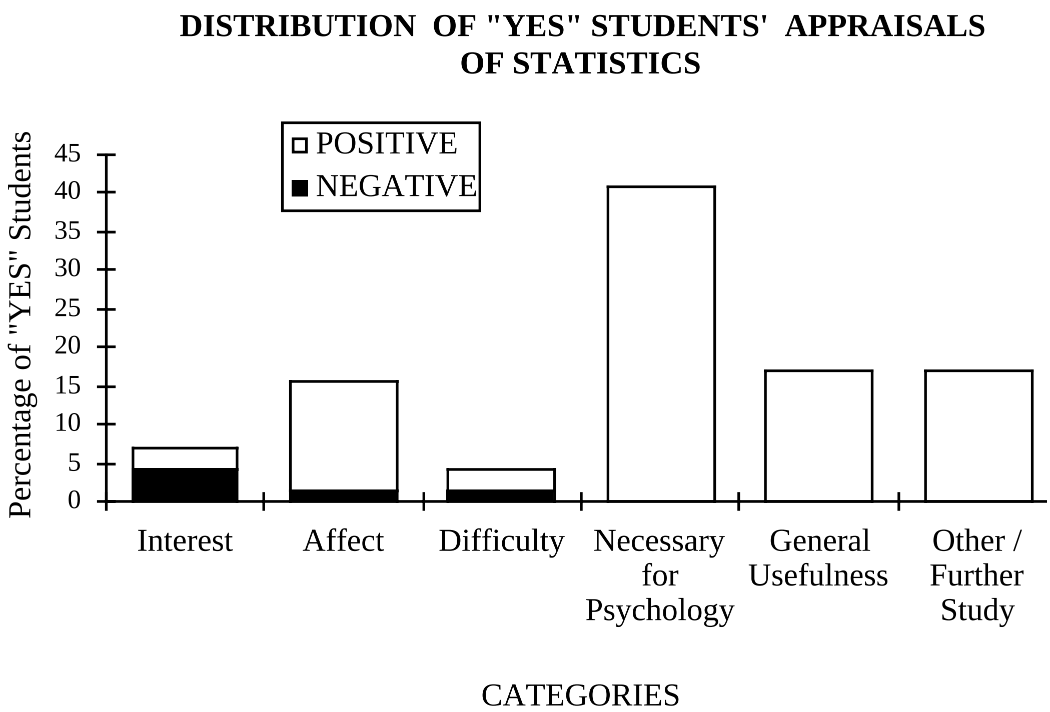


Figure 6.3.1, above, shows the distributions of reasons for “NO” students (N=204) and “YES” students (N=71) in the three categories of highest frequency for each of these groups. These bar graphs show that the reasons given by the “NO” students were dominated by personal, adverse perceptions of Statistics or beliefs about its difficulty. The reasons given by the “YES” students on the other hand were mainly that Statistics was essential to psychology, or responses were in terms of the perceived usefulness of Statistics — in society generally, or to other study. Only two of the “YES” students reported that Statistics was interesting, but, unlike the “NO” students, this played little part in their appraisals. Hence, rather than reflecting opposite sides of the same coin, the reasons given by students willing to study Statistics related primarily to extrinsic factors, while the reasons given by the reluctant majority related mainly to intrinsic elements, what Semenov (1978, p. 5) calls the “personal plane”.

6.3.4 Summary Of Students’ Appraisals Of Learning Statistics

A large majority of the participants in Study Two reported that they would not have studied Statistics, had they been given a choice. The most frequently given positive responses were that Statistics is necessary for psychology or that it is useful — in general “real world” applications, for studying or for carrying out research. However, responses to the first open-ended survey question were dominated by negative reasons. Many responses concerned the lack of appeal of Statistics — to these students the subject was boring or hard or they did not enjoy it. There were no responses referring to Statistics as personally relevant.

This has important implications for teaching statistics as a service course. If educators stress the usefulness of the subject to their fields they may be preaching to the converted. Students’ subjective evaluations in terms of interest and affective elements also need to be addressed. On Leont’ev’s first level of analysis (see section 2.4.4.2) it is motivation that determines the individual’s activity (Leont’ev, 1981). Actions are driven by motives and the ways in which these motives emerge and develop in their socioculturally organised settings govern the structure, quality and transformations of the activity — in this case how students engage with the learning task. The findings of this section suggest that those participants of Study Two who expressed positive reasons for studying Statistics had “internalised” (Leont’ev, 1981) extrinsically endorsed reasons for doing so, for example the necessity of Statistics to psychology as a discipline. Few reported that Statistics had “personal sense” (Leont’ev, 1978) for their long term goals or self fulfilment.

6.4 CONCEPTIONS OF STATISTICS

The focus of this section is the phenomenographic analysis of students’ responses to the three open-ended survey questions, in order to understand and categorise the students’ conceptions of Statistics. The three questions are reproduced below.

Question 1
Would you study statistics if it were not a requirement of your psychology course? Please give reasons for your answer.
Question 2
Think about the statistics you’ve done so far this year.

a) *How do you go about learning it?*
b) *What are you trying to achieve?*

Question 3
What in your opinion is this statistics course about?
Please explain as fully as possible.

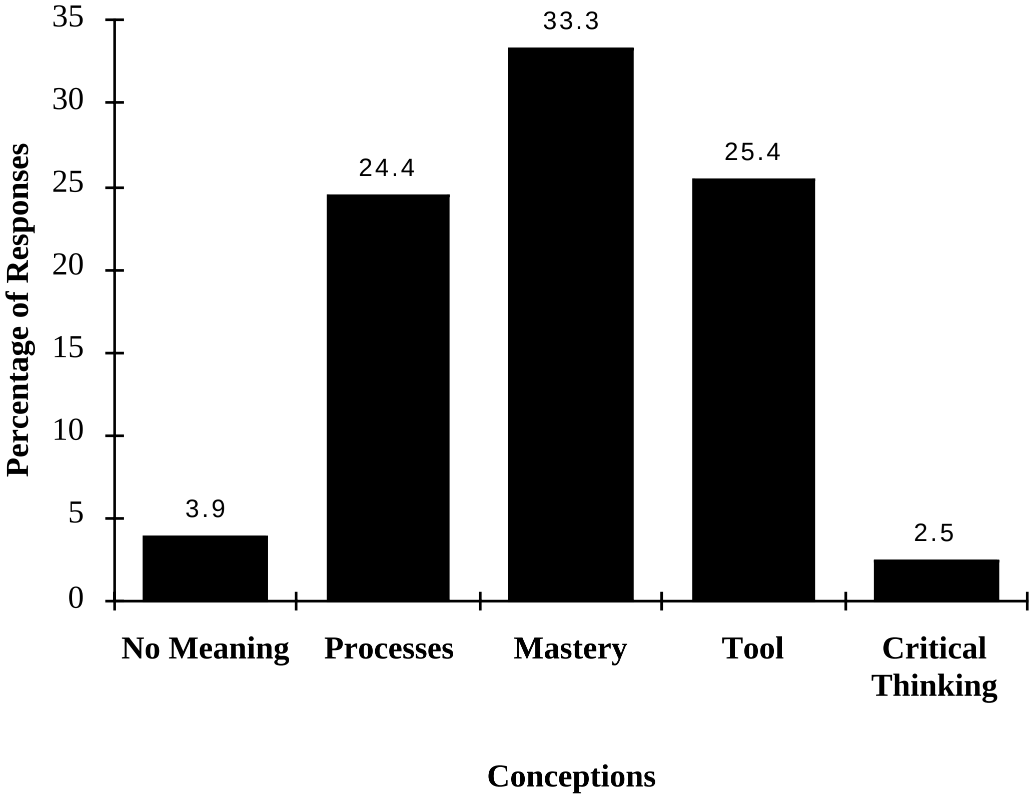
Phenomenographic analysis is unlike content analysis. Both these analyses are interpretative and subject to the world view of the researcher. However, my analysis of students’ appraisals of learning Statistics, described in the previous section (6.3) referred specifically to students’ responses to the survey Question 1 (shown above) and only to Question 1. The categories of conception were developed from the phenomenographic analysis and were inferred from what students wrote in response to all three open-ended questions. As advocated by Marton (1986) boundaries between students’ responses to different questions were ignored. That is, although a student’s response to Question 3 was important, it was her overall response to the three questions that enabled my colleague and myself to classify her conception of the subject, Statistics, into one of the categories we had formed (see section 4.5.5 for full details). Further, unlike the categories of students’ reasons derived from the content analysis of section 6.3, the phenomenographic categories form a logical and empirical hierarchy based on inclusion. That is, except for the NO MEANING category, which I will explain in section 6.4.2, each conception category subsumes a conception or awareness of Statistics expressed in the previous categories. This structure will be further clarified in section 6.4.4.

6.4.1 Overview Of Categories Of Conception

Five categories for students' conceptions emerged from the phenomenographic analysis. They are: NO MEANING; PROCESSES or ALGORITHMS; MASTERY of statistical concepts and methods; a TOOL for getting results in real life and CRITICAL THINKING. These categories will be explained in the next section (section 6.4.2). The following bar graph (Figure 6.4.1) indicates the distribution of students' responses into the five categories. The percentages shown in Figure 6.4.1 are out of 279, the number of students surveyed. Twenty nine students (10.4%) gave insufficient information for their responses to be classified into one of the Conception categories. These data will be treated as missing.

FIGURE 6.4.1

DISTRIBUTION OF STUDENTS' REPORTED CONCEPTIONS OF STATISTICS



6.4.2 Description of Categories for Students' Conceptions of Statistics

This section describes the qualitatively different categories for students' conceptions. A label for each of the categories is given below. Labels are followed by descriptions of that category and a number of illustrative excerpts from students' written responses. I have indicated which parts of the quotes (if any) are excerpts from students' responses to Question 1 or Question 2 as part of my "audit trail" (Lincoln & Guba, 1985, p. 319) mentioned in Chapter Four (p. 99).

CATEGORY 1: NO MEANING (N=11, 3.9%)

Students' responses indicating perceptions of Statistics as meaningless or unconnected to their goals in learning psychology, worthless, or set by the university as a means to confuse or "cull" less able students, were classified in this category. Five of the responses classified in this category (with their code numbers) are reported below.

166: *Trying to confuse me;*

261: *You tell me I just learn;*

239: *About 28 weeks;*

49: *I don't know*
(from Question 1) *It is boring and pointless for my future;*

150: *It is about the Uni having something they can use as a means to assess our performance. I assume that Psychologists use computer programmes to do everything we have learned in a matter of seconds.*

Hence this category of responses indicates a perception of Statistics as being without value or relevance.

CATEGORY 2: PROCESSES or ALGORITHMS (N=68, 24.4%)

Responses were classified in this category if:

a) The student's responses to the question consisted of a list of one or more statistical procedures;
b) The student described Statistics in terms of processes or algorithms — mechanical ways of dealing with data.

Examples of responses listing procedures are:

151: *Tabulating data;*

272: *testing hypothesis;*

259: *trying to find correlations*
to accept / reject null.

Examples of responses indicating a perception of the course as being about mechanical processes or coding are reproduced below. These indicate that a problem is entered and an answer or conclusion is produced via an algorithm.

128: *Learning to manipulate and tabulate data;*

115: *The Lecturer's Black Box example (or analogy) of stats. "You don't have to understand how it works, just be able to get the right answer";*

24: *operational level of understanding*
ie have number X $\rightarrow$ *get result Y;*

267: *Statistical results from experiments*
(from Question 1) *It's not necessary, considering computers do all the work;*

226: *Number crunching;*

292: *Interpretation of data using a set of formulae & rules w/o the use of a fully comprehensive* why *element.*

In summary, this category, which I will refer to as the PROCESSES category, is characterised by conceptions of Statistics as consisting of disconnected and mechanical techniques for solving classroom problems.

CATEGORY 3: MASTERY OF STATISTICAL CONCEPTS AND METHODS (N=93, 33.3%)

This category includes the understandings described in the previous category — algorithms and technical processes, but, in addition, the responses indicate an awareness of conceptual material and interpretation. Responses were classified in this category if students reported their conceptions of Statistics in terms of competence in technical skills, knowledge of facts and understanding of underlying statistical concepts — as presented in class. Typical responses included some or all of the following: analysing or interpreting given data; coming to conclusions on the basis of decontextualised information; solving practice exercises. In short, reading and/or understanding statistical information as prescribed for assessment and in isolation from the rest of the study of Psychology. Excerpts follow.

129: *Basic stats to give an overview of stats in psych.*
(from Question 2b) *Adequate knowledge to do well in psychology;*

290: *The course is about teaching us how to understand & use the data we receive from experiments*
(from Question 2b) *I am trying to achieve a basic understanding of the material & concepts & an ability to work out the problems. This will hopefully lead to a good result at the end of the year*;

248: *To give us a broad feel of what statistics is about*
(from response to Question 2b) *To do the very best I can;*

34: *Teaching us general concepts about stats in the vain hope that we will find it remotely interesting; a precursor for those intending to do Honours courses in psych*
(from Question 2b) *A mastery of the course; I realise that this will not be all that difficult to achieve so I feel that putting all my effort into stats*

> *would be disproportionate to the marks that I will achieve not to mention being completely unnecessary.*

Students whose responses were classified in this, the modal category, expressed perceptions of Statistics as being about interpreting and understanding the set problems. As reported by these students, Statistics was viewed in terms of information to be accumulated and stored in order to meet the assessment demands in the subject.

The MASTERY category differs qualitatively from the PROCESSES category in that the former denotes a more conceptual and cohesive view of Statistics than the latter. However, both these categories express a view of knowledge as performance in the academic context. The next two categories identify a shift in the students' thinking — students' conceptions move from an exclusively institutional context into the wider world and society.

CATEGORY 4: A TOOL FOR GETTING RESULTS IN REAL LIFE (N=71, 25.4%)

Responses in this category refer to the use of Statistics in conducting research or to its use in society. While some of these responses specifically alluded to notions expressed in the previous categories — for example, algorithms and competence in analytical methods, a student's reported conception was only categorised as a TOOL if it also included the idea of Statistics as an applied subject which could be used. It is noteworthy that not all students who thought statistical knowledge was applicable stated an intention to actually use that knowledge. Indeed only a minority (17 students, 6% of the 279) of the 71 students whose conceptions were classified in the TOOL category indicated conceptions of the subject as being personally beneficial.

Examples of responses indicating conceptions of Statistics as a TOOL are listed below in two groups: those who expressed the idea that the Statistics could be (but not necessarily would be) applied and those whose conceptions included the idea of personal purpose.

The following excerpts are examples of responses indicating that the subject could be used.

147: *It is an attempt to give psychology students insight into stats & experimental method, to enable them to do psychological research if they choose to follow psychology as a career;*

180: *teaching us the basics, as if continue with Psych, it is quite relevant & important in any* <u>*research*</u>
(From Question 2b) *to understand it, so to apply it*
(From Question 1) *I personally - no use for it, though it is useful;*

70: *It is about exposing and preparing Psychology students for research in psychology;*

146: *It is a useful course for people who intend to do experimental studies in Psychology, since it's the only way of collecting and analysing data in a systematic way.*
(From Question 1) *I don't see it as necessary in my future career ... .*

The following are examples of a more personal, purposeful, view of Statistics as a tool.

169: *Using statistics to apply it to experiments we will use later on in careers in psychology. A practical course;*

44: *A basic framework of statistics that allows for easy reference in many other aspects of psychology. Without this course, the rest of the psychology course would have little value.*
(Question 2b) *Knowledge;*

208: *giving us a grasp of stats so that when we are practising psych we can interpret our results.*

Logically, a student who conceived of Statistics as a tool, would also be aware of the subject matter as pertaining to underlying concepts and methods which must be understood. Empirically, many students expressed both these notions.

However, the awareness expressed in this category extends beyond the idea of knowledge as performance in assessment, signified in the previous two categories. The TOOL category designates a conception of Statistics as knowledge that could be applied to get results in real life.

CATEGORY 5: A WAY OF CRITICAL THINKING (N=7, 2.5%).

Responses were classified in the final category if they referred to Statistics as being about a (mathematical, scientific) way of critically evaluating findings, or organising, communicating and interpreting findings. Only seven responses were classified in this category. These responses attest to an added awareness of Statistics, compared to that expressed in the previous category. The conceptions of the subject not only related to its use for getting results in the real world but also its providing a perspective on those results.

104: *Stats is about methodology which is used as a comprehensive form of analysis to interpret and test theories & correlations psychologists create. Substantiated method.*
(from Question 2a) *Statistics is structured mathematics & should be considered as a friend to psychology;*

293: *Understanding how numbers can providence evidence for or against some hypothesis you are testing. As a way of ensuring the validity & reliability of your own research methods. To understand how numbers can be used to falsify data/conclusions.*

In this category Statistics is evidently viewed as a way of gaining insight into statistical thinking; an awareness of both the complexity and limitations of statistics as it is used in psychology or the broader world — a way of communicating. In summary this category expresses conceptions of Statistics as a basis for the scientific method.

6.4.3 Distribution Of Conception Categories According To Willingness To Study Statistics And Gender

Table 6.4.1, below, shows the percentage of students in each category of conception, divided into students who reported their willingness to study Statistics (“YES” students) and those studying it only because it was compulsory to do so

(“NO” students). The final column summarises the overall frequency distribution for the participants in the five categories as shown previously in Figure 6.4.1. The modes for each row are in bold font, to highlight the structural shifts. The percentages shown are column percentages, that is out of 204, 71 and 279, respectively. They are rounded to whole numbers except where the percentage is less than 1%.

TABLE 6.4.1

NUMBER OF “YES” AND “NO” STUDENTS IN EACH CONCEPTION CATEGORY

Category	“NO” Students (N=204)	“YES” Students (N= 71)	Total (*N=279)
NO MEANING	**11 (5%)**	0	11 (4%)
PROCESSES	**61 (30%)**	7 (10%)	68 (24%)
MASTERY	**75 (37%)**	17 (24%)	93 (33%)
TOOL	36 (18%)	**35 (49%)**	71 (25%)
CRITICAL THINKING	1 (0.5%)	**6 (8%)**	7 (3%)
Unclassified conceptions	20 (10%)	6 (8%)	29 (10%)

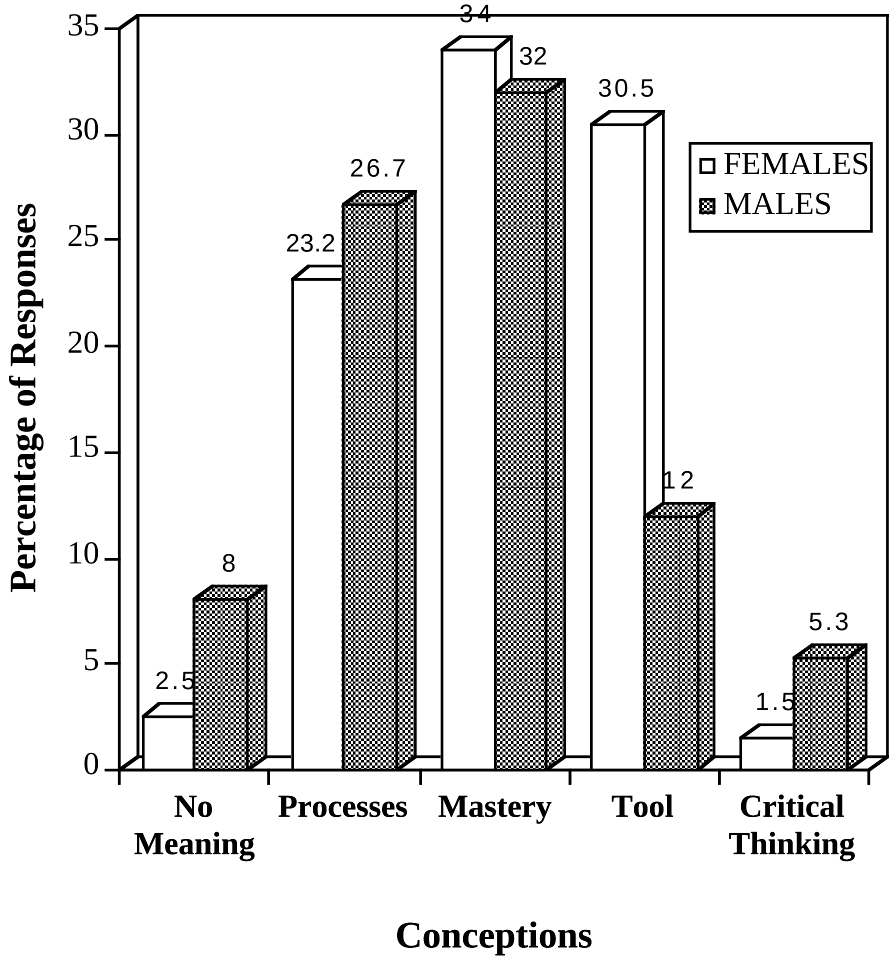
* Four students could not be classified as “YES” or “NO”.

Table 6.4.1, above, shows big differences in the categorised conceptions between the students willingly studying Statistics and those who were not. Over 70% of the “NO” students were classified in the first three categories, compared to 34% of the “YES” students. In particular, the modal category for the “NO” students was MASTERY while for the “YES” students it was TOOL. The differences in the frequencies for the “NO” and “YES” students were statistically significant in two categories: PROCESSES and TOOL (chi-square>8, $p<0.01$, in each case). As can be seen, a substantially higher number of the “NO” students reported conceptions of Statistics in terms of mechanical processes or algorithms than the “YES” students. On the other hand, far more of the students who would evidently have chosen to study Statistics, as opposed to those who would not, reported their awareness of its applicability (TOOL category). Further, only 2 of the "NO" students in the TOOL category (1% of the "NO" students) expressed conceptions of Statistics as a personally useful tool compared to 15 (21%) of the "YES" students. Statistical tests are inappropriate for the NO MEANING and CRITICAL THINKING categories as some cell frequencies are zero or one, but clearly the differences are substantial and are in the expected directions. These findings indicate strong links between willingness to study Statistics and conceptions of it.

Figure 6.4.2, below, and Table 6.4.2 (p. 182) show the gender differences in students' conceptions of Statistics. The heights of the bars in the graph (Figure 6.4.2) indicate the percentages of male (N=75) and of female students (N=203) whose responses were classified into each of the five Conception categories. Gender information is missing for one student. Conceptions could not be classified in the cases of 12 males (16%) and 17 females (8.4%). It would appear that a number of students, particularly males, were unable or unwilling to articulate their thoughts in answer to the survey Question 3. This was an unfamiliar question and one to which students were asked to supply their own answer, rather than choosing from given alternatives.

The gender patterns are very interesting. In particular, as Figure 6.4.2 shows, there appears to be a big difference between the proportions of males and females whose responses were classified in the TOOL category. This difference between the observed and the expected frequencies for males and females in the TOOL category was statistically significant (chi-square=7.4, $p<0.01$). From this analysis it appears that far more females than males related Statistics to the world around them. However, in the small group of 7 students whose reported conceptions were classified in the CRITICAL THINKING category, 4 were males (5.3% of the males) and 3 were females (only 1.5% of the females). While the CRITICAL THINKING group is small (and statistical tests inappropriate) this does represent an important gender shift.

FIGURE 6.4.2
DISTRIBUTION OF STUDENTS' REPORTED CONCEPTIONS OF STATISTICS ACCORDING TO GENDER



The apparent anomaly between the proportions of females and males whose conceptions were classified in the TOOL category compared to those in the CRITICAL THINKING category led me to reassess the gender patterns in terms of the different conceptions recorded at the TOOL level. As I explained in section 6.4.2, a student's conception was classified in the TOOL category if the response took one of two forms: either indicating that Statistics could be applied to get results in real life or suggesting that Statistics was seen as personally relevant — a tool that was currently useful or potentially beneficial for that student. Table 6.4.2, below, summarises the distribution of students' reported conceptions of Statistics according to gender, including the sub-division of the

TOOL category. This table shows that of the 62 females whose conceptions were classified at the TOOL level, only 12 (5.9%) expressed some personal commitment to using Statistics. The males, however, were divided almost equally into the two sub-categories of the TOOL classification. Five of the 9 males in the TOOL category (that is, 6.7% of the males) expressed the idea that Statistics was personally relevant. All 7 students classified at the CRITICAL THINKING level reported conceptions of Statistics as relevant to their concerns or future lives. In summary, 24.6% of the females (50 females) and 5.3% of the males (4 males) reported on Statistics as a general tool (but not a personal tool) that could be applied to get results in real life. However, only 7.4% (15) of the females compared to 12% (9) of the males reported Statistics as personally relevant — either as a TOOL or a way of CRITICALLY THINKING which they actually intended to use or were already using. Hence, while more females than males indicated an awareness of the utility of Statistics as a tool in the real world, these findings suggest that in most of the females' minds this tool was destined to remain in the "tool kit".

TABLE 6.4.2

NUMBER AND PERCENTAGE OF MALE AND FEMALE STUDENTS IN EACH CONCEPTION CATEGORY

Category	Female Students (N=203)		Male Students (N= 75)	
NO MEANING	5	(2.5%)	**6**	**(8.0%)**
PROCESSES	47	(23.2%)	**20**	**(26.7%)**
MASTERY	**69**	**(34.0%)**	24	(32.0%)
TOOL (General)	**50**	**(24.6%)**	4	(5.3%)
TOOL (Personal)	12	(5.9%)	**5**	**(6.7%)**
CRITICAL THINKING	3	(1.5%)	**4**	**(5.3%)**
Unclassified conceptions	17	(8.4%)	12	(16%)

One student did not provide gender information.
Modes for each category are shown in bold font.

Additional information about males' and females' conceptions of Statistics as a "real life" tool was provided by their responses to item 4 of the Approaches to Learning Statistics Questionnaire (ALSQ). This item is reproduced below. There was no statistically significant difference between the mean item score for females (2.45) and that for males (2.6) on this item. Females, it seems, did not relate Statistics to the world around them more than males did.

While I am studying statistics I think of real life situations in which the material that I am learning would be useful. 1 2 3 4 5

My interpretation of the apparently paradoxical results concerning females' awareness of Statistics as a tool is that females, more than males, internalised their teachers' reasons for including Statistics in the curriculum of Psychology II. That is, females were more likely than males to express conceptions of Statistics according with the institutionally endorsed meaning of Statistics — as important and integral to psychology — rather than reporting conceptions based on their own concerns alone. This will be discussed further in Chapter Nine (section 9.2.3.1)

6.4.4 Summary Of Categories Of Conception

The following table (Table 6.4.3) summarises the Conception categories emerging from students' responses to the open-ended questions of the survey and the view of knowledge expressed by each category. I illustrate each category by means of one representative excerpt from a student response.

TABLE 6.4.3
CONCEPTIONS OF STATISTICS: LEVELS OF AWARENESS

Category	View of Knowledge	Example of Response
NO MEANING	imposed, irrelevant	*You tell me, I just learn.*
PROCESSES Mechanical techniques or algorithms	disconnected: for reproduction in assessments	*... You don't have to understand how it works, just be able to get the right answer.*
MASTERY reading and understanding material as presented in class	as information to be accumulated and stored in order to meet the demands of assessments	*... I am trying to achieve a basic understanding of the material & concepts & an ability to work out the problems. This will hopefully lead to a good result at the end of the year.*
TOOL a) General use	a) could be applied in real life	*a) It is an attempt to give psychology students insight into stats & experimental method, to enable them to do psychological research if they choose to follow psychology as a career.*
b) Personal	b) useful to me	*b) Using statistics to apply it to experiments we will use later on in careers in psychology. A practical course.*
CRITICAL THINKING a perspective on the ways in which data is used to make decisions.	a scientific way of thinking and communicating; insight into the complexity & limitations of statistical theory	*Stats is about methodology which is used as a comprehensive form of analysis to interpret and test theories & correlations psychologists create. Substantiated method.*

Table 6.4.3, above, shows the hierarchy I proposed at the beginning of section 6.4. As discussed, this hierarchy was established in terms of inclusiveness. With the exception of the NO MEANING category, higher categories logically include the awareness expressed in lower categories. That is, a response classified in a higher category indicates to me not only an awareness of the conceptions described in the lower categories, but also shows added understanding. This is a logical hierarchy. Empirically, too, many students' responses indicated a conception of Statistics encompassing two or more categories (excluding the NO MEANING category). In these cases their conceptions were classified into the "highest" of the categories indicated. Finally, although the merit of the conception was not used to determine the hierarchy, the higher categories can be seen to express more educationally desirable conceptions of Statistics than the lower ones. Statistics is taught as a service course. Teachers of Statistics hope that students will find it a useful tool which will have impact on their lives and continued learning.

6.5 APPROACHES TO LEARNING STATISTICS

In this aspect of Study Two I am concerned both with the constitution of the Approaches to Learning Statistics Questionnaire (ALSQ) for gauging deep and surface approaches to learning Statistics and the characterisation of students' learning by means of scores on its Deep and Surface Scales.

6.5.1 The Approaches To Learning Statistics Questionnaire (ALSQ)

The ALSQ consists of 18 of the 28 items completed by students in the survey (see Appendix F: Learning Statistics Questionnaire). Initially the 28 items were based on the Study Process Questionnaire (Biggs, 1987) and the Approaches To Learning Mathematics Questionnaire (Crawford et al, 1995; 1998), as explained in section 4.5.6. Consistent with these questionnaires, even numbered items are considered to indicate deep approaches to learning Statistics, while odd numbered items are considered to indicate surface approaches to learning Statistics. The following data analyses was done using the software package SPSS (Norusis, 1990).

6.5.1.1 Scale Reliabilities

Initial analysis was carried out on all 28 items completed by the students. I used the Cronbach alpha coefficient, a common indicator of the internal consistency, on the two scales consisting of odd and even numbered items respectively. The alpha coefficient indicates the extent to which the items in the scale "agree" with each other (Biggs, 1987, p. 30). That is, it is a way of assessing the scale's reliability, indicating the extent to which the items are consistent. The inter-item correlation on the deep approach items indicated that internal consistency would be increased by omitting items 6 and 12. A number of students wrote on the survey that they did not understand item 12, so perhaps this is the reason for its poor correlation with other deep approach items. Item 6 consists of two ideas and I believe that some students agreed with one or other portion of the item, rather than with the item as a whole.

I defined the Deep Scale for the ALSQ as the scale consisting of the following 12 items: 2, 4, 8, 10, 14, 16, 18, 20, 22, 24, 26, 28. This scale yielded α=0.86, indicating a high level of internal consistency. This coefficient compares favourably with internal consistency results obtained by Biggs with samples of university students on the Deep Approaches Scale of the Study Process Questionnaire, which ranged from 0.65 to 0.81 (Biggs, 1987, p. 28). It is also similar to the two values of Cronbach's alpha (0.86, 0.87) obtained on two successive occasions, about six months apart, on the Deep Approaches Scale of the Approaches to Learning Mathematics Questionnaire (Crawford et al, 1995; 1998).

Scales indicating surface approaches to learning have consistently resulted in lower reliability than those denoting deep approaches in previous research (see Biggs, 1987; Crawford et al, 1995; 1998). My reliability analyses indicated that the maximum internal consistency on a scale indicating surface approaches to learning Statistics would be achieved by using a Surface Scale consisting of the following six items: 5, 7, 13, 21, 23, 27. For this scale, α=0.70. This value is in the middle of the range of Cronbach alpha coefficients (from 0.60 to 0.75) cited by Biggs on the Study Process Questionnaire, but lower than the alpha coefficients (0.78, 0.77) obtained on our two trials of the Approaches to Learning Mathematics Questionnaire (Biggs, 1987; Crawford et al, 1995; 1998).

By restricting the number of Surface Scale items to six, I narrowed the construct of a surface approach. Students who gained high scores on the six items were evidently concerned with uncritically memorising details, as presented by their teachers, in order to satisfy the demands of assessments. From this point on, I will refer to this construct as a surface approach to learning Statistics as it is similar, though not identical, to the construct developed by Biggs (1987) and is consistent with the interpretation of a surface approach to learning given by Marton, Watkins & Tang (1997) as discussed in section 2.3.2.2.

My Approaches to Learning Statistics Questionnaire (ALSQ) is the questionnaire consisting of two scales — the Deep Scale, consisting of the twelve items listed above and the Surface Scale consisting of six items, as described.

6.5.1.2 Item Factor Analyses

Justification for the items of the ALSQ to be divided into two scales, each denoting a different approach to learning Statistics, was provided by factor analysis. A principal components factor analysis was carried out to explore the structure of the relationships among the eighteen items which make up the Deep and Surface Scales. This was followed by a varimax rotation. Four factors were identified with eigenvalues greater than 1. These eigenvalues are 5.34, 1.39, 1.43 and 1.26.

The aim of factor analysis is to account for as much of the variance as possible with a solution which is both interpretable and economical (Cattell, 1966, 1978; Child, 1978; Kerlinger, 1973). The four factors which I extracted accounted for 57.3% of the variance. Factor 1 links items from the Deep Scale which mainly indicate that students find learning Statistics interesting. Factor 2 links items from the Deep Scale which suggest that students seek personal meaning from their learning, while items that load highly on Factor 3, again from the Deep Scale only, indicate that students adopt a cohesive approach to learning Statistics, relating it to other material. I have interpreted these factors as FIND INTERESTING, SEEK PERSONAL MEANING, and RELATE TO OTHER MATERIAL. As the fourth factor links items from the Surface Scale only, I have interpreted it as ADOPT SURFACE APPROACH. Some overlap was found among the first three factors, all of which show high positive loadings of items from the Deep Scale, but there was no overlap with items from the Surface Scale.

Table 6.5.1 below summarises the rotated factor matrix. The items have been ordered so that the six items which make up the Surface Scale are shown first, followed by the twelve items which make up the Deep Scale. Loadings smaller than 0.44 and negative loadings are omitted in the table in order to clarify the structure. Decimals are correct to two places and decimal points have been omitted.

TABLE 6.5.1
ROTATED FACTOR MATRIX ON ITEMS OF THE ALSQ

ITEM	Factor 1: FIND INTERESTING	Factor 2: SEEK PERSONAL MEANING	Factor 3: RELATE TO OTHER MATERIAL	Factor 4: ADOPT SURFACE APPROACH
5				62
7				62
13				59
21				44
23				57
27				79
2		75		
4			80	
8		44	46	
10		71		
14	77			
16			64	
18	47	62		
20	79			
22	85			
24		48		
26	56			
28			74	

Since there was no overlap among the items loading positively and highly on Factor 4 (the Surface Scale items) and the items loading positively on the other three factors (the Deep Scale items) a two factor solution seemed reasonable. The two factor solution after varimax rotation is shown, below, in Table 6.5.2. The two factors account for 42.5% of the variance and have eigenvalues of 5.33 and 2.32.

TABLE 6.5.2
PRINCIPLE COMPONENT FACTOR ANALYSIS WITH TWO FACTORS, USING VARIMAX ROTATION

ITEM	Factor 1: DEEP APPROACH	Factor 2: SURFACE APPROACH
5		70
7		55
13		68
21		54
23		48
27		66
2	61	
4	48	
8	45	
10	61	
14	76	
16	64	
18	76	
20	74	
22	65	
24	67	
26	68	
28	46	

Decimals are correct to two places with decimal points omitted.
Negative loadings and loadings smaller than 0.2 are omitted in the table.

The factor analysis shown in Table 6.5.2, with two factors extracted, supports the structure of the ALSQ I proposed above. That is, the six items I classified as representing surface approaches loaded positively and highly on one factor, and the twelve items classified as representing deep approaches to learning Statistics loaded positively and highly on another, separate, factor.

6.5.2 Statistics For Deep And Surface Scales

Each item on the ALSQ has a possible score of between 1 and 5 with high scores indicating that the student usually adopted the approach to learning Statistics suggested by that item. On average, students had considerably lower scores on the Deep Scale than on the Surface Scale.

Table 6.5.3, below, shows that the average item score for the Deep Scale was a low 2.19, compared to an average Surface Scale item score of 3.43. This substantial difference between the item means for the Deep Scale and Surface Scale is statistically significant (paired $t=-8.66$, $p<0.001$, $N=264$).

TABLE 6.5.3
DESCRIPTIVE STATISTICS ON DEEP AND SURFACE SCALES

	Mean	Median	Standard Deviation	Cases
Deep Scale	2.19	2.08	0.68	267
Surface Scale	3.43	3.5	0.81	270

Moreover, for the vast majority of the surveyed students (214 students, 77%) the average item score on the Surface Scale exceeded the average item score on the Deep Scale. This indicates that over three quarters of the students adopted surface approaches to learning Statistics more frequently than deep approaches.

Females had statistically significant, higher scores, on average, than males on the Surface Scale of the ALSQ ($t=2.98$, $p<0.01$). The item mean for females on this scale was 3.53 (standard deviation 0.76, N=196) while males attained an average of 3.18 (standard deviation 0.90, N=73). On further analysis I found that while the mean item scores were higher for females than for males on all six items of the Surface Scale, these gender differences were greatest (at least 0.5) and statistically significant ($p<0.01$) on items 5, 13 and 27 (see Appendix F for items). This suggests more concern about assessment and a greater reliance on the authoritative view of Statistics by females than males.

Average scores on the Deep Scale do not differ significantly for males and females. However, on two items of the Deep Scale: item 20 and item 22, differences are statistically significant ($p<0.05$). On these two items males scored on average somewhat higher than females (0.3 or less) although the means for both sexes were low on these two items — at most 1.8. Both of these items are concerned with the level of interest in Statistics.

In general, the lowest average item scores were on the five items loading positively and substantially on Factor 1 of the Deep Scale — FIND INTERESTING (see Table 6.5.1). The mean item score on these five items was only 1.67 (with standard deviation 0.69, N=269). A few students even indicated on their survey papers that had a rating lower than 1 (“only rarely”) been available for these items they would have chosen it. This is consistent with the findings in section 6.3 that the most frequent reason cited by students, in response to the first open-ended survey question, was they found Statistics uninteresting. Mean item scores on the other two subscales of the Deep Scale (SEEK PERSONAL MEANING and RELATE TO OTHER MATERIAL) were also low: 2.44 and 2.67 respectively (with standard deviations 0.83 and 0.87 and N=270 and 273, respectively).

On average, the students expressing reluctance to learn Statistics (“NO” students) scored substantially lower on the Deep Scale and substantially higher on the Surface scale of the ALSQ than those reporting that they would have chosen to study Statistics (“YES” students). Table 6.5.4, below, shows the different means and other descriptive statistics for “YES” and “NO” students. The differences between the means on the Deep and Surface Scales are statistically significant ($t>5.6$, $p<0.001$ in each case).

TABLE 6.5.4
DESCRIPTIVE STATISTICS FOR “YES” AND “NO” STUDENTS ON DEEP AND SURFACE SCALES

DEEP SCALE

	Mean	Standard Deviation	Cases
“YES” Students	2.56	0.64	69
“NO” Students	2.06	0.64	194

SURFACE SCALE

	Mean	Standard Deviation	Cases
“YES” Students	2.89	0.68	71
“NO” Students	3.64	0.77	195

Given that most of the participants of Study Two viewed the task of learning Statistics as imposed — a demand to be met which lacked personal relevance — it is to be expected that they would tend to adopt surface approaches to learning it. Most did not want to learn Statistics. It is therefore unlikely that they would strive to make the learning personally meaningful, interesting, or cohesive — the hallmarks of the deep approach. The statistics quoted above for the Deep and Surface Scales are in the predicted direction. This supports the validity of the Deep and Surface Scales in the sense of substantiating the sense and recognisability of these results. What each scale purports to denote is credible. The structure of the ALSQ fits with a qualitative analysis of students' approaches to learning Statistics.

6.6 PERFORMANCE IN ASSESSMENTS

The final mark for Statistics is the average of the following four components: the class mark, based on "open-book" tests or quizzes, and the examination mark for semester one and, similarly, the class mark and examination mark for semester two. These tests and examinations are not available for reproduction in my appendices as they are kept confidential from students and teachers and similar versions are re-used from year to year. For this reason I was also not able to inspect the tests or examinations. From my discussion with the lecturer of Statistics it appears that the assessments involve problem solving which aim to test students' conceptual understanding of the content. The student shows her full working in the "open-book" class tests. The two multiple choice examinations include problems involving calculations (about one third of the examinations) and questions for which no calculations are required. About half the questions (less in the first semester) are embedded in contexts related to psychology, such as problems concerning memory or reaction times; the others test skills and techniques. The (raw) means on the four assessment tasks for the whole Psychology II class were: 58%; 50.6%; 62.7% and 53.1% respectively, yielding an overall average of 56.1% (with standard deviations 24%, 20.4%, 21.6% and 22.5% and overall standard deviation 22%). The final examination in semester two was completed by 340 Psychology II students. The minimum pass mark for Statistics is 40%.

The following table, Table 6.6.1, summarises the means and standard deviations of the surveyed students on the four assessment tasks and on the final mark in Statistics (calculated by averaging the marks on the four components for each student). All marks are unscaled (raw) and are expressed as percentages correct to one decimal place. As can be seen, these averages are higher for the participants of Study Two than for the Psychology II class as a whole. Although a matter of conjecture, it is possible that the students who did not attend the Statistics lecture during the week the survey was completed, were, in general, less engaged with the learning task than the participants of Study Two, who were at least present. Table 6.6.1 also shows that the participants of Study Two performed, on average, considerably better on the "open-book" class tests than on the multiple choice examinations in both semesters (paired $t>5.8$, $p<0.001$, in both cases).

TABLE 6.6.1
DESCRIPTIVE STATISTICS FOR SURVEYED STUDENTS' PERFORMANCES ON ASSESSMENT TASKS

Variable	Mean (%)	Standard Deviation (%)	Cases (N)
Class Tests, Semester 1	60.3	23.5	250
Examination, Semester 1	53.0	20.1	246
Class Tests, Semester 2	63.9	21.5	238
Examination, Semester 2	54.7	22.5	234
Final Statistics Mark	58.3	18.5	222

On the whole students performed consistently on the four components of the assessment. High positive correlations were found between students' marks on the class tests and examinations for both semesters. The Pearson's correlation matrix is shown below in Table 6.6.2. All correlations are statistically significant ($p<0.01$).

TABLE 6.6.2
PEARSON'S CORRELATION COEFFICIENTS FOR ASSESSMENT TASKS IN STATISTICS

	Class Tests, Semester 1	Class Tests, Semester 2	Examination , Semester 1	Examination , Semester 2
Class Tests, 1	1.00			
Class Tests, 2	0.67	1.00		
Examination, 1	0.64	0.58	1.00	
Examination, 2	0.62	0.64	0.61	1.00

The following finding explodes the myth that ability in the general area of Psychology and prowess in Statistics are mutually exclusive. There was a strong correlation of 0.62 ($p<0.01$) between students' final mark in Statistics and their overall marks on the other areas of Psychology II (excluding Statistics).

Interestingly, there was a substantial and statistically significant, positive correlation between students' expected grades in Statistics (Fail, Pass, Credit, Distinction or High Distinction) reported in section 6.2, and their final marks in the subject (Spearman's Correlation Coefficient 0.61, $p<0.001$). Students' expected grades in Psychology II also correlated positively and statistically significantly with their actual performances, although less strongly (Spearman's Correlation Coefficient 0.34, $p<0.001$).

Males outperformed females in Statistics (statistically significant, $t=2.58$, $p<0.05$) achieving a final (rounded) mean score of 64% (standard deviation 18%, N=55) compared with the females' mean of 57% (standard deviation 18%, N=166). This difference was due mainly to the superior performance of the males in the multiple choice examination in semester one (statistically significant, $t=3.2$, $p<0.01$). While the males obtained a mean score of 60% on this assessment task, the females' average was only 51%. No statistically significant differences were found between the sexes in the other three assessment tasks in Statistics nor in the students' results in the non-statistical components of Psychology II.

Finally, students who expressed their willingness to study Statistics ("YES" students) performed far better, on average than the "NO" students in Statistics on all four assessment tasks. Table 6.6.3, below, summarises these differences.

TABLE 6.6.3

PERFORMANCE OF "YES" AND "NO" STUDENTS ON ASSESSMENT TASKS

	Means for "YES" Students	Means for "NO" Students
Class Tests, 1	70% (19%, 65)	57% (24%,181)
Class Tests, 2	73% (15%, 65)	61% (23%, 170)
Examination, 1	59% (17%, 65)	51% (20%, 178)
Examination, 2	63% (21%, 63)	52% (22%, 168)

Standard deviations and number of cases shown in parentheses.
Percentages rounded to whole numbers.
Differences between means statistically significant, $t>2.9$, $p<0.01$.

The mean final mark in Statistics for the "YES" students was 66% (standard deviation 14%, N=60). This was considerably higher than the mean of 55% attained by the "NO" students (standard deviation 19%, N=159). The difference between the means was statistically significant ($t=4.1$, $p<0.01$). However, no statistically significant difference was found between the means of these two groups on final performance in Psychology II excluding Statistics (mean for "YES" students: 67%, mean for "NO" students: 66%). This suggests that motivation to learn Statistics, rather than general ability or effort, was the factor most implicated in the different average performances on Statistics for these two groups of students.

In summary, students' increased motivation to study Statistics was reflected in considerably better performances on all assessment tasks.

6.7 ILLUSTRATIVE EXTRACTS FROM INTERVIEWS WITH TWO STUDENTS

I have tried to capture some general patterns in students' conceptions of Statistics and approaches to learning it from the survey responses of the participants of Study Two. However, such responses were limited by students' willingness and ability to express themselves in writing and were, by necessity, brief. Hence, the richness and diversity of individual experiences were lost. The following extracts from interviews with two students capture some of the individual complexity lost in the previous analysis. I have given a guide to the interview questions in Appendix H. I firstly report on each student's survey responses and secondly on the interview data.

Table 6.7.1, below, summarises the survey data and marks in Statistics of the two students. Neither student would have chosen to study Statistics, had it not been compulsory. Initially, both students' conceptions were classified as MASTERY. However, in Colin's case this categorisation was tentative, as his written responses were very brief and somewhat cryptic. After analysing his interview data this classification was changed to CRITICAL THINKING. The reasons for this change will be explained in section 6.7.2. As indicated by their scores on the ALSQ, Ruth and Colin adopted very different approaches to learning Statistics. Neither student did well on the Statistics assessments.

TABLE 6.7.1

SUMMARY OF DATA FOR RUTH AND COLIN

	Ruth	Colin
CHOICE	No	No
CONCEPT	MASTERY	CRITICAL THINKING
Deep Scale (Mean Item Score)	1.7 (Z=–0.8)	2.8 (Z=0.8)
Surface Scale (Mean Item Score)	4.7 (Z=1.5)	2.8 (Z=–0.7)
Age	19 years	45 years
Mark in Statistics	50%	*40%

*Colin's final Statistics mark and his marks on the class tests are missing from my data. However, he scored 40% on each the two multiple-choice examinations.

6.7.1 Ruth

In her survey Ruth wrote the following responses to the three open-ended questions.

Q1: *no, I am no good at maths*

Q2a: *trying to memorise formulas and trying to understand/apply concepts and formulas*

Q2b: *pass the course*

Q3: *teaching us how we find data in psych and extending our ability to solve problems.*

Hence, although Ruth expressed some preoccupation with applying formulae, her responses also suggested an awareness of Statistics being about conceptual understanding and examining data. I interviewed her in order to try and clarify this awareness.

6.7.1.1 Interview With Ruth

Ruth's plans were to be a "counselling psychologist". When I asked how Statistics fitted into her plans, her response indicated that, on the whole, she thought studying Statistics was pointless and irrelevant to her future. She said:

> A little bit in, perhaps, research. And maybe, possibly, a little bit with working with certain individuals — working out where they fit in the scale of the population. But a lot of it doesn't seem to fit for me. It seems — extra — only necessary if you want to be really heavily into doing things, research and that. For example, when we do a distribution and we have to find the variance and we have to find the number of people in it, and all that sort of thing. It seems so pointless, because if I do a test — if I do an experiment, I'm going to know that. And this manipulation seems to be a little bit pointless. We're never going to have to use it again.

I asked Ruth how she was going about learning Statistics? Her answer indicated a high reliance on rote learning:

> I try and understand. But if I can't, I go back to rote learning. I'm trying to understand more, but basically I always fall back to rote learning. I just write it out one hundred times or so until I know the formula backwards. Sometimes I might practice using it, but very seldom. It's usually only trying to get it to stick in my head that I can know it.

Ruth's aim was to pass the examinations. However, she indicated that she also hoped also to gain some knowledge and perspectives which would go beyond the immediate examinations.

> I was hoping that in the exams that would be what we'd be asked. That sort of thing. That at least I'd have remembered something, that it would stay there. But other than that, it's not doing anything.
>
> I'd like to understand it for next year. I don't want to have wasted time. To have nothing to show for it. And have no added knowledge or no added systems of doing things. It would be nice to have learned some logical ways — some logical methods. But it would be nice to pass the exams. Just that.

Ruth had bad memories about learning mathematics at school.

> I didn't hate it, but I couldn't understand it and it frightened me, generally. Got the frozen fear reaction and couldn't understand it at all. And then the teacher I had from year ten to year twelve. He was a male teacher. He would say it once. And he would get very impatient. And in the end I just stopped asking because it was hard and it was embarrassing to ask all the time. He was very good at maths but he was a perfectionist. And he expected us to do that too. And I'd fail exams and I wouldn't want to go and ask.

I asked what in particular had given her trouble in mathematics. She replied:

> Concepts, mainly concepts. But also some of the symbols and the formulas. I would not know how to use them at all in a test situation. And it left a very bad impression. This particular formula was really bad because every time I looked at it I failed.

However, she did not feel the same way about Statistics.

> I relate to it a bit differently. The environment's a bit different which is better. Most of the tutors I feel comfortable with. And the way they explain things is more basic — not expecting that you know — which is a lot easier. And the Statistics, too isn't on the same level. It's not as frightening as year twelve maths. It doesn't have a lot of the

> concepts that used to really frighten me. The things that gave me the frozen fear reactions.

> It's more trying to understand. Its more trying to give an understanding rather than just answers. It's not just the answer on the page. It's understanding how you get to it. ... You can write down and explain that you've understood it. Instead of using things like $P(OBS \mid H_0)$ — that sort of thing. You can say that you understand rather than just having to use formulas.

Hence, as in her survey, Ruth indicated an awareness that in addition to involving procedural knowledge, understanding Statistics also involved interpreting and communicating ideas.

I tried to probe what Ruth meant by "understand". Ruth explained that by understanding she meant feeling confident and being able to communicate her understanding. She knew that she had understood it:

> generally when I can explain it to someone else. And also when I can sit down in a situation, away from all my notes and stuff and feel reasonably confident. I don't get frightened, I don't get thrown off. And I get the right answer. It may take me time but I don't get lost. I don't get lost! I tend to do that in tests — just mill around.

Ruth felt constrained by her fear of tests and examinations and the lack of time to get on top of the work.

> Generally, especially in the last exam I had, I'll see the question on the page and — there's just a feeling that there's something missing. For example, I'll know how to do a certain thing using Z scores. But there's no Z score there. And it frightens the life out of me. I spend most of the time trying to figure that out and then realise that I didn't need it anyway. So I wasted my time and I just wandered around doing something that wasn't really beneficial to finding the answer. That generally is what happens.

> Generally, I just try to get the formulas straight in my head. I practised using formulas this time. Sometimes, if it's a really simple test, I will practise a lot. Examples and using formulas, trying to find things in the formula. But when it gets more difficult, I usually revert back to just trying to learn the formula without understanding.
>
> It's difficult. Because for all the subjects we have reading to do. And also the Statistics course itself. When we have a test we also have a tutorial scheduled, so we'll get a sheet and we'll just have to go over it in our spare time. Sometimes I don't have time for that. So it means that I'm not getting as much practice or even as much explanation because of the amount that's jammed in. And also all my other work.

I asked what she would do differently if she had more time. She said this:

> I think I'd start reading the text the night before the lecture. Getting a grip on that. And possibly doing more of the examples from the text book. More of the practice questions from the tuts (tutorials) too. If I had more time. I may even go back and listen to my lecture tapes over and over.
>
> Just to reinforce it. To get it into my head more than once. To get the reinforcement. And also, I'd be able to pick up if I didn't understand something. Sometimes in a lecture she'll say something that will confuse me. But by the time I go back to it the confusion's gone and I've forgotten what the question was. And if perhaps I'd read it the night before (rather) than after the lectures, it would be easier to deal with that problem straight away. Instead of it coming up in an exam situation where I really didn't understand.

It seemed that Ruth hoped to gain a mastery of the concepts and ideas from the Statistics course.

> Hopefully an understanding of Statistics. And also the ability to — a system where I can work things out for myself. Where I don't always have to go back to a formula or a book. ... I should be able to work

> things out without necessarily having to stop every three seconds to figure out where I'm at.

The interview with Ruth substantiated much of what she had written in her survey concerning her appraisal of learning Statistics, her conception of it and her approach to learning it. Ruth, clearly, would have preferred not to study Statistics given a choice. Her conception of Statistics appeared to fit best in the MASTERY category, although it was a borderline case. Had I been ranking students' responses within this category, hers would be at the "lower" end. Ruth's description of her aims and strategies strongly indicated that she usually adopted a surface approach to learning Statistics. There was also little indication of the engagement, interest or cohesive approach associated with deep approaches to learning. The interview data were consistent with her high score on the Surface Scale of the ALSQ and her low score on the Deep Scale.

6.7.2 Colin

In his survey, Colin responded "no" to the question of whether he would have studied Statistics even if it had not been compulsory. For his reason he simply wrote:

Q1: *need*

This could mean that he felt he needed Statistics, but in view of the "no" it probably meant that he was compelled (needed) to do it. The latter interpretation seemed to fit with a statement he made in the interview:

> It's part of the psychological course so I have to fit it in.

Colin's written responses to the other two open-ended survey questions indicated his engagement and difficulty with the subject. They also hinted at an awareness of Statistics as underlying the scientific method for analysing information.

Q2a: *repetition & grappling with the concepts*

Q2b: *understanding*

Q3: *scientific paradigm*

6.7.2.1 Interview with Colin

Colin was evidently very interested in my research despite having written such brief responses on the survey sheet. He arrived in my office a few days after the surveys had been completed and volunteered to be interviewed. He explained why in the interview.

> I thought if anyone could assist you it would possibly be me because I'm one who really ... . I've had to overcome this problem which means I've had to put in a lot of time and thought and all the rest of it to it.

An older student, Colin explained his plans:

> Well, I'd like to enter into the psychological field somewhere along the lines and I think, possibly, I'll be aiming at counselling — possibly patients of my own age and experience. Given that I appreciate that the younger psychologists may be more articulate than I am, I've had life experience which I think the older patients would relate to much better. So that's what I'm aiming at.

His father's profession meant that the family moved frequently, to the detriment of Colin's education.

> My family got moved from one state to another, one schooling system after another. At that time, in the 50's and 60's, each state had its own curriculum and the curriculum was different between city and the country.
>
> But mathematics — I can do the normal existential stuff: add, subtract, multiply and divide. But anything over that I didn't really worry about. I didn't bother with it mainly because I was having difficulty with it.

Like Sandra and Hettie in Study One, Colin came to an awareness that learning mathematics was an activity in Leont'ev's (1981) terms: requiring motivation to grapple with the problems it posed.

> As I've got older I've realised it's a bit of a mental exercise and you just have to commit yourself — and struggle through and work out why you're having difficulties and seek help. It takes a long time for some of us. That's what I'm doing now.

Colin explained how he felt about learning Statistics and described his activity — how he engaged with the task.

> It's part of the psychological course so I have to fit it in. I can understand the general thrust of why we have statistics. How we arrive at them sometimes is — I won't say a mystery. I think the only reason I say it's a mystery is that I haven't grasped the concepts. And the way I've been trying to come to terms with the concepts is just to do the exercises I find in text books and try and picture in my own mind what it is I'm trying to do. And trying to balance my conclusions as to the conclusions in the text. Sometimes they agree, sometimes they disagree.
>
> I'm a bit pig headed in that I like to address my own problems and most probably wait until the nth moment — and then go and look for help. So I'm going through trying to get things sorted out in my own mind. If I have much more difficulty by the end of this week, then I'll be coming to say: "Can you help me with this?" or "Can you give me a set of exercises to cover these particular lectures of stats, and sit down and work through one or two with me to see where my conceptual problems are?" — and possibly address it from there. But at this stage I'd like to battle on a bit longer and see how I go. I'm getting there, but it just seems to take forever.
>
> Certainly, I've been around long enough to know that some people have skills and some people don't. I think as far as mathematics is concerned I'm one of the latter. It doesn't mean I can't learn it — it just means its a g-d almighty struggle to come to terms with it.

Colin was using the exercises to make sense of the Statistics so that he would be able to answer questions set for tests and examinations.

> I think I'm trying to work out why I'm having a problem in being able to interpret a question. And be confident that I've understood the question in the first place. And then confident that I had the tools to answer the question. That's a pretty grey area. You know, I got 6 out of 10 in the stats test. I went through the stats test and did what I understood straight off and then came back to the ones that I wasn't certain of and looked at them again and tried to come up with some answers. But I wasn't very confident that I was approaching it from the right angle.

Colin's difficulties were evidently with the language of mathematics, apparently on two levels. One was to recognise and translate symbolic language into his own functional language. The other was to be able to communicate his own understanding so that it was universally understandable.

> My difficulty with that more than anything else is being able to manipulate the symbols in the work itself so that someone else recognises it. It took me a while to sort of come to terms with that. ... It's just a slow, laborious crawl uphill — of coming to terms with something that I recognise, rather than something everyone else might recognise.
>
> As I come across a problem I sit there for two or three weeks ... . Until I grapple with it and I come to that sort of arrangement which satisfies the general understanding as well as my own.
>
> Expression is a problem and I feel inhibited to a certain extent in that I can't express myself smoothly. And getting over the problem of being too formal. I can still use plain, objective language but stats takes a little while to manipulate and push out. It's a battle but I enjoy the challenge. Some days I enjoy it less than I do others.

Colin adopted a deep approach or a surface approach to learning Statistics, depending on his intention at the time. He explained that he knew he had understood something when he had connected the concepts and consolidated his understanding.

> When I can do two or three questions phrased differently or approached from another angle and come up with the right answers. Where I'm confident that I've got the strategies incorporated.
>
> I don't know if I can actually put my finger on it other than it's taken me a long time and a lot of repetition to get it stuck in here (my head). I enjoy the lectures and I can retain it for that period of time. But after the lecture ceases — it fades. That's why I'm doing the repetition type exercises to try get it well and truly entrenched and incorporated.
>
> All we have to do is persevere and try and grope for the concepts. But it's a grope!

I asked Colin what he hoped to gain from the Statistics course. He replied:

> Just an understanding of how stats are manipulated or can be manipulated and how I can manipulate them myself if I carry on in the psychological world and I have to do experimental papers. Then I can use the scientific or statistical paradigms to pick up any research I might do.

I probed by asking Colin directly whether he was mainly trying to get through the course or whether he saw himself applying Statistics. One of his aims was evidently to pass the course. However, he again expressed the idea that Statistics could be a useful tool to him — a systematic way of analysing results in the real world and communicating these results in accordance with accepted scientific thinking.

> It's mainly to get through the course and also to apply it to when I'm in practice in some description or another. ... Well, doing my own research if I get into practice. If I come across something interesting, like I decide to pursue a particular subject — I can write an experimental paper and back it up with statistics which are recognised and accepted by the scientific world. Whether I get there — well, that's in the future.

> I am also much more aware of the stats which are quoted in the media. The various biases which are there, for those who know how to recognise that the bias exists in the first place. Its beneficial.

As mentioned at the beginning of section 6.7, my colleague and I initially categorised Colin's conception of Statistics as MASTERY. This was based on our interpretation of his survey responses before we had analysed any interview data. Discussion of Colin's interview responses led us to change our categorisation of Colin's conception of Statistics from MASTERY to CRITICAL THINKING — a systematic way of analysing results in the real world. His cryptic written response to the survey Question 3, reporting Statistics as being about a "scientific paradigm", seemed to mean using the scientific paradigm provided by a knowledge of Statistics to analyse "real" experimental findings, rather than merely mastering classroom exercises on contrived experimental findings. This meant that Colin, alone of the 7 students whose conceptions of Statistics were classified as CRITICAL THINKING, answered "No" to the first survey question — indicating a reluctance to study Statistics. However, Colin was an older student with very little background in mathematics. From the interview data it seems apparent that his difficulties with Statistics, rather than his perception of its lack of relevance, led to this reluctance. This interpretation was supported by Colin's response of 5 (almost always) on item 4 of the Approaches to learning Statistics Questionnaire (ALSQ). This item is reproduced below.

While I am studying statistics I think of real life situations 1 2 3 4 5
in which the material that I am learning would be useful.

Ruth, for example, on the same item, circled 1 (only rarely).

The interview with Colin led me to treat with caution other students' written comments, particularly when they were brief, ambivalent or enigmatic. Colin had expressed doubts about his own ability to express himself. Others, too, must have had similar problems. Unlike Colin, most students who had written very little on the survey sheet did not make themselves available for an interview, so I was unable to clarify their responses even if time had been available to interview all such participants.

6.8 SUMMARY AND CONCLUSION

In this chapter I have answered the five sub-principal research questions of Study Two. The variables I have described include demographic variables, the students' reasons for their willingness or reluctance to study Statistics, the categories for the students' conceptions of Statistics, their approaches to learning Statistics and their assessment results. The key findings of my analysis are summarised below.

Most of the participants had studied mathematics at a level which included Calculus. Over 90% of them expressed the intention to study Psychology beyond second year. The students were overwhelmingly reluctant to study Statistics, because they found it boring or difficult, although the subject was acknowledged by some as being necessary for psychology or useful. A range of conceptions of Statistics was held by the students. However, most of the participants expressed conceptions of the subject in terms of understanding the prescribed content and solving the problems presented in class, unrelated to the practice of psychology and isolated from the wider world. Consistent with this majority view of the subject matter and their negative attitudes to studying Statistics, most students tended mainly to adopt surface approaches to learning it, as indicated by scores on the Approaches to Learning Statistics Questionnaire. Three underlying factors of the Deep Scale of the ALSQ were found by factor analysis. The first related mainly to interest in learning Statistics, the second related to how personally meaningful the students found the learning and the third related primarily to relational understanding. Mean item scores on all these factors were low (at most 2.7) but especially so for level of interest. Four different assessment tasks were given to the students. Achievements on all of these were, on the whole, consistent, and also agreed well with students' self ratings of their likely grades in Statistics. Students' marks in Statistics correlated positively with their academic attainments on the non-mathematical components of Psychology II.

I did not intend gender to be a focus of this study. However, as will be clarified in Chapter Nine (section 9.2.3.1) gender roles are part of the sociocultural context surrounding students' actions (Hofstede, 1991). Gender differences are therefore important for my investigation from an activity theory perspective. Males are a minority in this study. Three important gender differences were found. Firstly, statistically significantly more females than males expressed an awareness of Statistics as a TOOL. However, further analysis revealed that these conceptions did not deem Statistics to be a personally useful tool. Secondly, female students had (statistically significant) higher average scores on the Surface Scale than males. In particular, their mean scores on the Surface Scale items suggest that the females in this study were more concerned about assessment and more accepting of authority than males. Thirdly, females had (statistically significant) lower marks on the multiple choice examination than males in the first semester, but not in the second semester. Hence, the females may have learned what was expected of them after the feedback of the first examination, or there may have been general changes in students' learning patterns. Longitudinal research is needed in the area of statistics education to ascertain how patterns of learning develop during university study of statistics courses and to explore the factors relating to these unfolding patterns.

The findings of this chapter support Leontev's (1981) insistence that motivation is critical in defining activity — in this case how students engaged with learning Statistics. The students who reported that they would have chosen to study Statistics, if it had not been compulsory ("YES" students) had orientations to the learning task that were very different from those who would not have studied Statistics given the choice ("NO" students). The reasons given by the "YES" students for their decisions centred, in general, on Statistics as an essential part of psychology or its utility, while the "NO" students focused mainly on their lack of interest in Statistics, dislike of mathematics or Statistics or the perceived difficulty of the subject. Over half of the "YES" students' conceptions of Statistics were in the TOOL or CRITICAL THINKING categories compared to less than 19% of the "NO" students. Further, very few of the "NO" students expressed conceptions of Statistics as personally useful. The "YES" students had a (statistically significant) higher mean on the Deep Scale of the ALSQ and a (statistically significant) lower mean on the Surface Scale than the "NO" students. Consistent with their greater engagement with the learning task the "YES" students performed considerably (and statistically significantly) better on all four assessment components during the year.

At this point, I have indicated some links between variables, such as between students' choice as to whether they would have studied Statistics if it had not been compulsory to do so (YES or NO) and categories of conception of Statistics or scores on the Deep and Surface Scales of the ALSQ. Variables have not yet been linked in any systematic way. However, a picture is emerging of a dynamic system where all the variables described form interlinking networks. These links will be explored further in the following chapters.

CHAPTER SEVEN

RESULTS OF STUDY TWO: UNDERSTANDING UNIVERSITY STUDENTS LEARNING STATISTICS AS A SERVICE COURSE TO PSYCHOLOGY

PART TWO — LINKING THE VARIABLES

7.1 INTRODUCTION

In this chapter different and complementary methods of data analysis are used to explore the network of relationships among the variables described in Chapter Six. These methods include correlations and factor analysis which illustrate links among variables. Cluster analysis shifts the focus from variables to students and it is used to identify groups of students with similar patterns of experiences in learning Statistics. The findings show striking trends and interdependencies among the variables and reveal cogent differences in students' experiences. Vignettes from interviews with selected students are used to illustrate four different profiles. These indicate that while the subject matter presented, institution and lecturer were the same for the students surveyed, students' orientations to learning Statistics were associated with a complex system of individual, social and contextual variables.

7.1.1 Chapter Preview

The previous chapter addressed the first five sub-principal research questions of Study Two. This chapter addresses the sixth sub-principal research question reproduced below.

What relationships can be found among the variables of interest?

- In particular, I am interested in the relationship between the categories of conception and students' scores on the Approaches to Learning Statistics Questionnaire (ALSQ).
- More generally, I investigate the inter-relationships among the following variables:
    a) category of conception;

b) willingness to study Statistics;

c) scores on scales denoting surface and deep approaches to learning Statistics on the ALSQ;

d) performance in tests and examinations;

e) previous level of mathematics studied;

f) age;

g) gender;

h) reported fluency in English;

i) previous level of statistics studied.

The sections of Chapter Seven address different aspects clarifying the relationships referred to in the above question. In section 7.2, I look at the relationships between the categories of conceptions, derived from students' responses to the open-ended questions on the survey, and students' scores on the ALSQ. In section 7.3, inter-relationships among the variables of interest are explored using factor analysis and cluster analysis. Qualitatively different patterns of experiences are highlighted by means of interview data. The conclusion (section 7.4) sums up the findings.

7.2 CONCEPTIONS OF LEARNING STATISTICS AND APPROACHES TO LEARNING IT

I first consider how students' reported conceptions of Statistics relate to their approaches to learning it. The variable, CONCEPT, denoting students' reported conceptions of Statistics, has five nominal values, according to the category in which the student's response was classified, namely NO MEANING, PROCESSES, MASTERY, TOOL and CRITICAL THINKING. Students' approaches to learning Statistics are indicated by the scores obtained on the Deep and Surface Scales of the ALSQ.

The line graphs, shown in Figure 7.2.1 (p. 212) show the strong relationship between the categories of conception, obtained from the phenomenographic analysis of students' responses to the open-ended questions on the survey, and their scores on the two scales of the ALSQ.

I obtained the line graph in Figure 7.2.1 for the deep approach versus conception category as follows:

1) I calculated each student's average item score on the Deep Scale of the ALSQ.
2) I then calculated the means of these for each group of students whose conceptions fell into the same category. Hence five means for deep approaches were obtained, one for each of the conception groups: NO MEANING, PROCESSES, MASTERY, TOOLS and CRITICAL THINKING.
3) The five averages were plotted and the points joined in order to guide the eye.

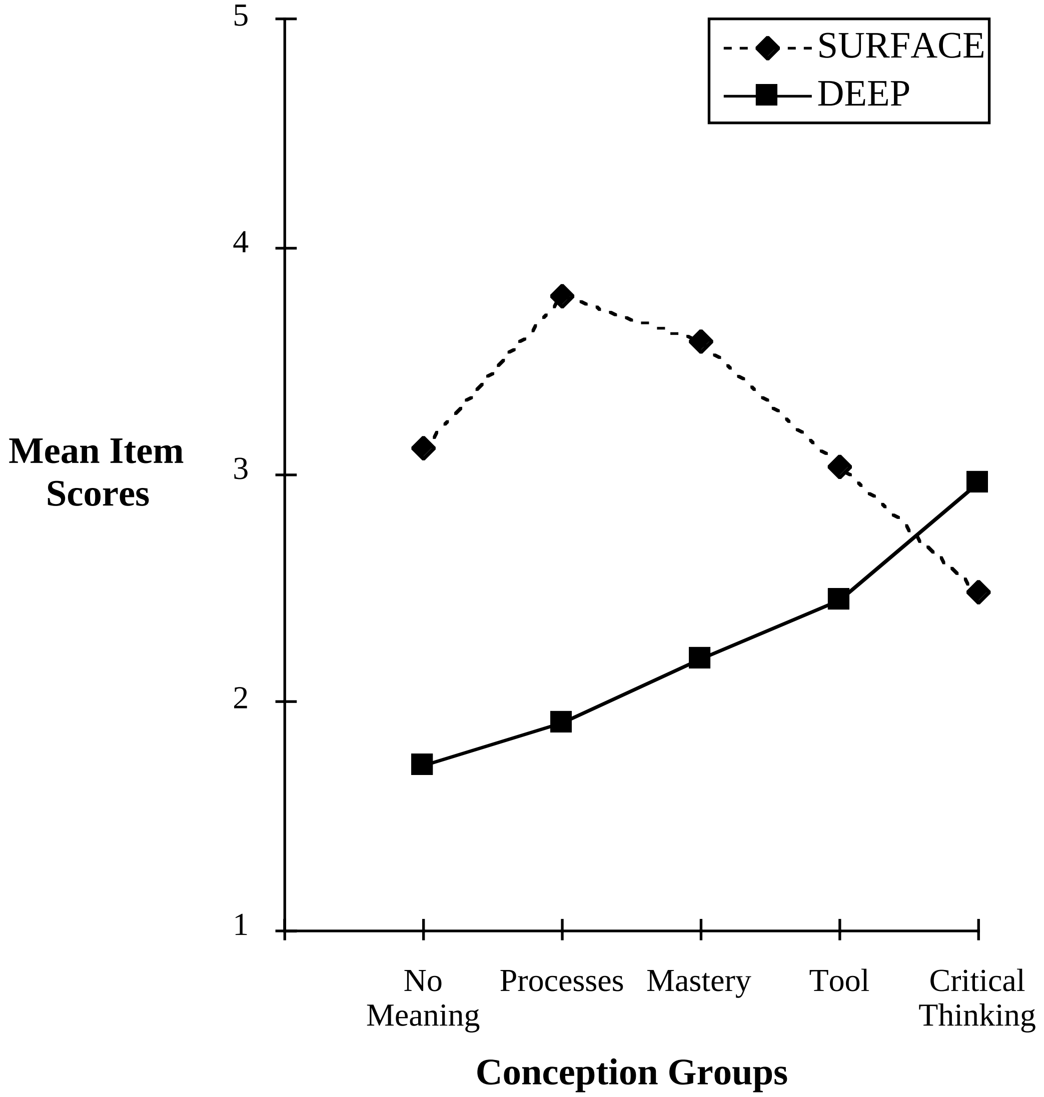
I applied a similar procedure to obtain the line graph for the surface approach versus conception category.

Figure 7.2.1 is followed by two tables (Table 7.2.1 and Table 7.2.2) showing the means and standard deviations for each of the five conception groups on the Deep and Surface Scales, as well as the number of cases for each group. In addition to showing the trends evident in the line graphs, these tables indicate the variability of the groups. In particular, the standard deviation for the small NO MEANING group is comparatively high on the Surface Scale of the ALSQ as are the standard deviations for the CRITICAL THINKING group on the Deep and Surface Scales. These groups are far from homogeneous.

A discussion of the patterns follows these graphs and tables.

FIGURE 7.2.1

MEAN ITEM SCORE FOR EACH CONCEPTION GROUP ON SURFACE AND DEEP SCALES OF THE ALSQ



Note: The Y-axis shows the range for Deep and Surface Scale items, from “1”, indicating that the student adopts this approach “only rarely”, to “5”, indicating that the approach is adopted “almost always”.

TABLE 7.2.1

SUMMARY OF DEEP SCALE RESULTS FOR CONCEPTION GROUPS

Category	Item Mean for Group	Standard Deviation	Cases
NO MEANING	1.69	0.39	11
PROCESSES	1.91	0.62	66
MASTERY	2.19	0.60	88
TOOL	2.45	0.64	69
CRITICAL THINKING	2.96	0.61	7
Overall	2.19	0.66	N=241

TABLE 7.2.2

SUMMARY OF SURFACE SCALE RESULTS FOR CONCEPTION GROUPS

Category	Item Mean for Group	Standard Deviation	Cases
NO MEANING	3.11	0.98	10
PROCESSES	3.79	0.66	66
MASTERY	3.61	0.75	90
TOOL	3.03	0.73	71
CRITICAL THINKING	2.48	0.87	7
Overall	3.44	0.81	N=244

Two important trends are apparent from Figure 7.2.1 and Tables 7.2.1 and 7.2.2. These trends were similar for males and females.

Firstly, the graphs and tables portray the overwhelming preference for surface approaches to learning Statistics expressed by the participants in Study Two. This is consistent with the analysis of section 6.5.2. Only for the small group categorised in CRITICAL THINKING was the average score on the Deep Scale of the ALSQ higher than the average score on the Surface Scale. This is strong evidence for the effect of context as asserted by Vygotsky and the activity theorists (Leont'ev, 1981; Vygotsky, 1978). Students' approaches to learning Statistics depend on their interpretations of the learning task within its setting. In this case surface approaches to learning Statistics evidently fitted with these interpretations.

Secondly, inspection of Figure 7.2.1 and Tables 7.2.1 and 7.2.2, above, reveals both a striking pattern and an apparent anomaly.

The pattern relates to the evident strong relationship between the categories of conception and scores on the two scales of the ALSQ. On average, scores on the Deep Scale increase with each increase in conception category while scores on the Surface Scale decrease with each increase in conception category with the exception of the NO MEANING group.

The anomaly refers to the unexpectedly low average score of the NO MEANING group on the Surface Scale. I expected that the students who conceived of Statistics as a meaningless and pointless subject would tend to adopt surface approaches to learning it. This proved not to be the case. These students did, however, have low scores on the Deep Scale, as would be expected. The unexpected result led me to examine more closely the NO MEANING students' responses to the open-ended survey question (Question 2) asking them about their strategies for and intentions in learning Statistics. These students were heterogeneous, having levels of prior mathematics ranging from 2 Unit Mathematics to university mathematics. However, my inspection revealed a common thread in their responses — these students evidently had a low level of engagement with the task. Their responses indicated that they were not attempting to memorise or rote learn the material presented, worrying about their performances on assessment tasks, attempting to conform to their teachers' ideas (as perceived) — they simply made the minimal effort required. As one of these students wrote, in response to Question 2a, her strategy was to:

> ignore it until I have to study for a test.

This finding adds further weight to my hypothesis that the NO MEANING category does not form part of the hierarchical structure of the conception categories (discussed in section 6.4). Hence, I suspended this group in some of the further analyses (correlations, factor analysis) carried out on the relationships among conceptions of Statistics and other variables, where hierarchical ordering of the selected variables is required. These analyses are described in section 7.3.1.

For the four category groups: PROCESSES, MASTERY, TOOL and CRITICAL THINKING, an increase in students' awareness about Statistics was accompanied by a change in their reported approaches to learning it. The means on the Deep Scale increased linearly over the four conception categories ($p<0.001$, $R=0.37$, $R^2=0.14$). The means on the Surface Scale decreased linearly over the four categories ($p<0.001$, $R=0.44$, $R^2=0.19$). As investigated, the ways that students conceive of the subject Statistics and their intentions and ways of learning it are strongly related. This supports Leont'ev's (1978, 1981) premise that mental reflections, goals and actions are inseparable. Students' conceptions of Statistics are expressed in actions taken, purposefully, to learn it and, conversely, their actions shape their conceptions of the subject.

7.3 PATTERNS OF EXPERIENCES

7.3.1 Associations Among Variables

In this section, I explore the structure of the relationships among the variables of interest. I initially explore the inter-dependence among the variables by investigating the correlation matrix for the ordered variables shown below. A label for each variable is shown on the right. In the case of categorical variables I have shown the values in ascending order in brackets underneath. Dichotomous variables such as GENDER have been arbitrarily ordered as 1 and 2. A full discussion of my treatment of variables is provided in Appendix K.

Note: The previous level of statistics studied (PRIOR STATISTICS) could not be included in this analysis as this variable is confounded with PRIOR MATHS. For example, at the time my survey was carried out, all first year mathematics courses at the University of Sydney included a statistics topic.

a) Category of conception Levels 2 to 5 (PROCESSES, MASTERY, TOOL, CRITICAL THINKING) I excluded the NO MEANING category (level 1) from the correlation analysis, since it is not logically or empirically part of the hierarchy, as supported by the finding in the previous section (7.2)	CONCEPT
b) Willingness to study Statistics (NO 1, YES 2)	CHOICE
c) Scores on the Deep Scale of the ALSQ	DEEP
Scores on the Surface Scale of the ALSQ	SURFACE
d) Performance on the four assessments That is:	
Class mark attained from open-book, tests and quizzes in semester one;	CLASS1
Examination mark attained on the multiple-choice examination in semester one;	EXAM1
Class mark attained from open-book, tests and quizzes in semester two;	CLASS2
Examination mark attained on the multiple-choice examination in semester two.	EXAM2
e) Previous level of mathematics studied Levels 1 to 6 (LESS THAN YEAR 12, MATHEMATICS IN SOCIETY, 2 UNIT MATHEMATICS, 3 UNIT MATHEMATICS, 4 UNIT MATHEMATICS, UNIVERSITY MATHEMATICS)	PRIOR MATHS
f) Age in years	AGE

g)	Gender (MALE 1, FEMALE 2)	GENDER
h)	Reported fluency in English Levels 1 to 3 (NOT FLUENT, FAIRLY FLUENT, VERY FLUENT)	FLUENCY

Table 7.3.1, below, shows the Pearson's correlations among the above variables of magnitude at least 0.30 ($p<0.01$ in all cases). Variables are correlated in pairs.

TABLE 7.3.1

CORRELATION MATRIX FOR CORRELATIONS OF AT LEAST 0.30

(EXCLUDING "NO MEANING" STUDENTS)

	CONCEPT	CHOICE (NO 1, YES 2)	DEEP	SURF	CLASS1	EXAM1	CLASS2	EXAM2	PRIOR MATHS
CONCEPT	*								
CHOICE	40	*							
DEEP	37	39	*						
SURFACE	–42	–44	–39	*					
CLASS1			34	–34	*				
EXAM1				–31	64	*			
CLASS2					67	58	*		
EXAM2					61	61	62	*	
PRIOR MATHS		32	31	–45		31		34	*
AGE									–30

Decimal points are omitted. Decimals correct to two places.

No correlations exceeding 0.30 were found relating to gender. However, lower but statistically significant ($p<0.01$) correlations were found between the variables GENDER (Males 1, Females 2) and EXAM1 ($r=-0.21$) and GENDER and SURFACE ($r=0.21$). This is consistent with the findings of Chapter Six (sections

6.5 and 6.6). No statistically significant correlations were found between FLUENCY in English and any other variable. This is not surprising in view of the fact that 90% of the students expressed themselves as VERY FLUENT (described in section 6.2). This variable was dropped from all further analysis.

The correlation matrix in Table 7.3.1 suggests links within groups of variables. For example, it supports the idea that there are relations among the variables indicating students' conceptions of Statistics (for levels 2 to 5), their willingness to learn it, their approaches to learning Statistics, and their levels of prior mathematics. It indicates that these students performed consistently on the four assessment tasks, as already described in section 6.6.* It appears that common dimensions or factors underpin the variables investigated, indicating that factor analysis would be fruitful.

Factor analysis has been called the "queen" of quantitative analytic methods, because of its power and elegance (Kerlinger, 1973 p. 659). It is a method of extracting common factor variances from sets of scores and therefore helps to determine the separate constructs which describe a large number of variables. I carried out a factor analysis on the variables which showed significant intercorrelations above: CONCEPT categories 2 to 5 (excluding the NO MEANING category); willingness to study Statistics (CHOICE: NO 1, YES 2); marks in tests and examinations (CLASS1, EXAM1, CLASS2, EXAM2); scores on the Deep and Surface Scales of the Approaches to Learning Statistics Questionnaire (DEEP, SURFACE); age in years (AGE) and gender (GENDER: MALE 1, FEMALE 2).

The method of factor extraction I used was a principal components analysis with varimax rotation (Norusis, 1990). In the principal components method, factors are extracted in an order that ensures that the first factor accounts for as much of the variance as possible. Subsequent factors, in turn, successively account for the maximum amount of the remaining common variance. Varimax rotation locates reference axes orthogonally in a way that is useful for eliminating ambiguities posed by some variables loading in a similar way on more than one factor. It does not change the number of factors or the interpretation of factors. Cattell (1978)

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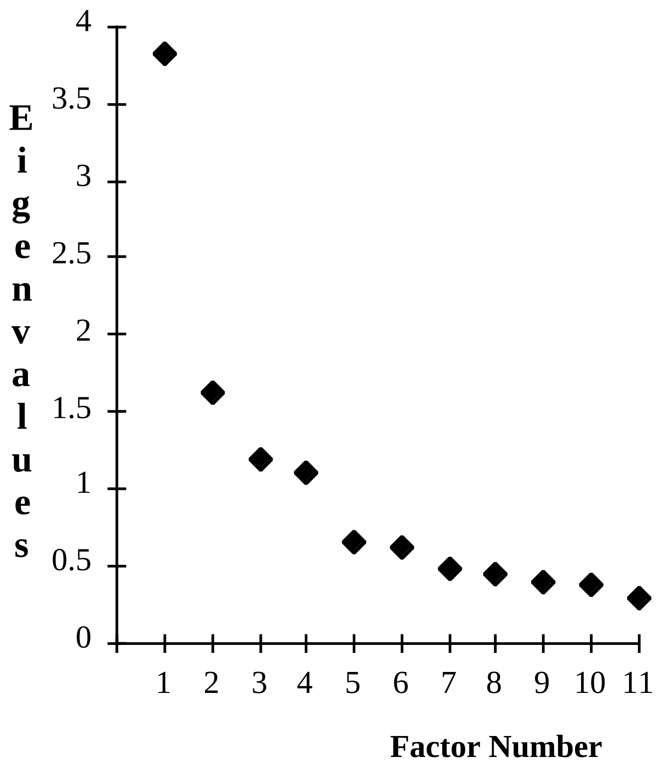
* Slight differences (of at most 0.02) between the correlations shown in Table 6.6.2 and Table 7.3.1 are due to the exclusion of the NO MEANING students in the latter.

also recommends oblique rotations which allow related variables. However, in this case I found oblique rotations did not lead to any change in my conclusions. Four factors were extracted, on the basis of Kaiser's criterion which states that only factors having latent roots greater than one are considered common factors (Child, 1978, p. 43). These eigenvalues were 3.82, 1.63, 1.18 and 1.10 respectively. Support for extracting no more than four factors was provided by the "scree" diagrams (Cattell, 1966, 1978, p. 62). The "scree" test, as described by Cattell, is a method of determining the number of factors by graphing the latent roots against the factor number (that is, order of extraction). The point at which the slope straightens out, so that the remainder of the curve resembles the scree-like debris which collects on the lower part of rocky slopes, is taken as the maximum number of factors extracted (see Figure 7.3.1). This seemingly naive way of determining the number of factors has extensive mathematical and empirical substantiation, as a reading of Cattell's work will testify. Cattell (1978) offers some guidelines to assist researchers decide on the cutoff point of the scree. These include a recommendation that more than three points are required for a scree and that a vertical break, which is sharp, though it may be small, separates the last point of the scree from the point above it. The scree diagram (Figure 7.3.1) suggests that the cutoff to the scree begins after the first four factors.

FIGURE 7.3.1: "SCREE" DIAGRAM



The four factors accounted for 70.3% of the variance (34.7%, 14.8%, 10.8% and 10.0% respectively). Cattell calls such factors “broad” factors since they show loadings across two or more variables (Cattell, 1978, p. 31).

The rotated factor matrix showing the loadings of the variables on the extracted factors is shown in Table 7.3.2, below. Only loadings of magnitude greater than 0.3 are shown in order to highlight the factor patterns.

TABLE 7.3.2

ROTATED FACTOR MATRIX

	PERFORMANCE	ORIENTATION	GENDER EFFECT	MATURITY EFFECT
CONCEPT (4 categories)		78		
CHOICE (NO 1, YES 2)		71		
DEEP		67		
SURFACE		–67	31	
CLASS1	84			
EXAM1	81			
CLASS2	83			
EXAM2	82			
PRIOR MATHS		51		–51
AGE				92
GENDER (M 1, F 2)			93	

Decimal points omitted. Decimals correct to two places.

As can be seen from Table 7.3.2, the first factor links the variables relating to performance on assessment tasks. Interestingly, the variables denoting deep and surface approaches to learning Statistics did not load to any notable extent on this factor. That is, although the directions of their loadings on factor one were as expected (positive for DEEP: 0.25, negative for SURFACE: –0.23) the loadings were small.

The second factor shows the positive relationship among variables indicating students' conceptions of Statistics (for levels 2 to 5), their willingness to study it, the level of mathematics studied previously and their scores on the Deep Scale of the ALSQ. The variable indicating scores on the Surface Scale of the ALSQ loaded negatively on this factor. It is notable that the level of mathematics studied previously, an important aspect of students' personal histories, loaded substantially on this factor, rather than with the performance variables. This supports Vygotsky's (1962) holistic approach which includes previous development and experience as an integral part of current thought and action. I have termed this second factor ORIENTATION, as four of the variables: CONCEPT; CHOICE; DEEP and SURFACE are the focus of my investigation into students' orientations to learning Statistics in Study Two, although the construct of orientation or positioning is more complex than a combination of the elements highlighted by the factor analysis.

The third factor indicates a link between females and surface approaches to learning Statistics, consistent with the findings of the previous chapter (section 6.5.2). The final factor indicates that age is negatively related to background in mathematics. Older students did indeed have less preparation in mathematics, as described in section 6.2.

In short, four factors were extracted, which I have labelled as PERFORMANCE, ORIENTATION, GENDER EFFECT and MATURITY EFFECT. Communality on the four factors was high for each of the variables investigated (see Table 7.3.3, below).

I do not wish to over-emphasise the values of the regression coefficients (loadings) since the variables are not interval variables, except for the four performance variables and AGE (see Appendix K). Nevertheless the factor analysis satisfies the goals of finding factors that are highly interpretable and describe the data parsimoniously (Kerlinger, 1973). The findings are consistent with the conclusions arrived at by other methods.

TABLE 7.3.3
COMMUNALITIES OF VARIABLES IN FACTOR ANALYSIS

VARIABLE	COMMUNALITY
CONCEPT (4 categories)	69
CHOICE (No 1, 2 Yes)	54
SURFACE	61
DEEP	58
EXAM1	73
EXAM2	70
CLASS1	76
CLASS2	71
AGE	88
GENDER (M 1, F 2)	88
PRIOR MATHS	66

Decimal points omitted. Decimals correct to two places.

In summary, my factor analysis of variables, excluding the scores of the NO MEANING students, indicates associations among the variables. It suggests a relationship among the variables linking motivation to learn Statistics, higher levels of awareness about Statistics, better preparation in mathematics and deep approaches, opposed to surface approaches, to the learning. The four variables describing students' performances are highly correlated and performance on them emerges as a separate dimension to the orientation factor. Age is related mainly to prior levels of mathematics studied, while the primary gender effect revealed by the factor analysis is to connect females with surface approaches to learning Statistics.

7.3.2 Differences In Student's Experiences Of Learning Statistics

Cluster analysis is a way of identifying subgroups of students, rather than scores, on the basis of similarity of scores on given variables. Clusters are determined so that the members of each cluster are closer to each other than to members outside the cluster with respect to the chosen clustering variables. In factor analysis, variables that are negatively correlated may load on the same factor as those that are positively related. Cluster analysis, however, can be done so that variables that are negatively related appear in different groups. I have used these two research devices in a complementary fashion to illustrate different aspects of the inter-relationships. I will discuss cluster analysis, as a way of interpreting data, in more depth in Chapter Ten (section 10.3.2.2).

There are many techniques for cluster analysis. Initially, I used the “average linkage” between-groups method (Norusis, 1990, p. 361) to determine the number of clusters that would be appropriate. This method is a hierarchical clustering technique that successively groups individuals into clusters by minimising “distances” between clusters. The distance between clusters is defined to be the average of the squared Euclidean distances between all pairs of cases in which one member of the pair is from each of the clusters. This process starts with as many clusters as there are cases and halts when all cases have been agglomerated into only one cluster. Hence the problem of the investigator is to decide at which stage the agglomeration process is to stop. The primary consideration is to avoid grouping together cases which do not belong in the same cluster. It is generally suggested that large changes between fusions are useful indicators of the appropriate number of clusters as these combine groups which are distant or disparate (Everitt, 1977; Anderberg, 1973). The steps in the hierarchical clustering solution produced by the SPSS CLUSTER procedure can be represented visually using “dendograms” (Norusis, 1990, p. 356). [*]These are tree diagrams displaying graphically the distances at which the clusters are combined. Inspection of these dendograms led me to decide that a two cluster solution would be appropriate to describe the data, as it was at the final stage, where two clusters were combined into one, that the distances between the clusters being combined appeared largest.

I then used the SPSS procedure QUICK CLUSTER (Norusis, 1990, p. 369) to produce the clusters. In this procedure the number of clusters is specified by the user. The cluster centres are estimated from the data. Each case is assigned to the cluster for which the distance between the case and the centre of the cluster (centroid) is smallest (Anderberg, 1973). The procedure is an agglomerative hierarchical method which is efficient in producing a solution once the number of clusters has been determined. The final cluster centroids (vector means) describe the profile for each cluster.

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[*] For an explanation of dendograms and examples, see Everitt (1977).

My aim was to complement the factor analysis by investigating more closely the relationship between students' performances on assessments and their approaches to learning Statistics. Hence, clustering was done on the variables for approaches to learning (DEEP, SURFACE) and performance (CLASS1, EXAM1, CLASS2, EXAM2). These six variables were first standardised (to Z-scores, with overall mean=0, standard deviation=1) to ensure that all the data units being clustered were of similar magnitudes. This is necessary for the procedures used. Data on the clustering variables was available for 211 cases. The NO MEANING students are included in the analysis as CONCEPT (denoting conceptions of Statistics) was not one of the clustering variables.

7.3.2.1 Two Cluster Solution

The profiles for the two clusters are shown in Table 7.3.4, below. The majority of the 211 students fell into the first cluster. This cluster was characterised by relatively poor performances, on average, on all four assessment tasks, below average scores on the Deep Scale of the ALSQ and higher than average Surface scores. In contrast, the profile of the second group was of students who, on average, performed well on the assessments, particularly on the class tests. Although still low, the average Deep Scale score for this cluster was above the overall mean for the 211 students (Z=0.39). The average Surface Scale score for this group of students was well below the overall mean (Z=–0.49). Z-scores greater than 0 (that is, above the overall average) are shown in bold font in the table. Statistical tests of significance are not valid, as cluster analysis guarantees "significant" differences between the pairs of means on all the clustering variables.

In summary, the two clusters differed dramatically on performance in tests and examinations and on approaches to learning Statistics. The mean final Statistics mark for the Cluster 1 students was 44.5%, while for those in Cluster 2 it was 75.1%, a substantial difference in achievement.

TABLE 7.3.4

STANDARDISED MEANS (Z-SCORES) FOR CLUSTER 1 AND CLUSTER 2 ON ASSESSMENTS AND APPROACHES TO LEARNING STATISTICS

	CLUSTER 1 Low Achievers; Above Average on Surface (N=114)	CLUSTER 2 High Achievers; Above Average on Deep (N=97)
CLASS1	–0.65 (45%)	**0.87** (81%)
EXAM1	–0.62 (41%)	**0.81** (69%)
CLASS2	–0.59 (51%)	**0.72** (79%)
EXAM2	–0.60 (41%)	**0.73** (71%)
DEEP SCALE	–0.30 (1.99)	**0.39** (2.45)
SURFACE SCALE	**0.37** (3.74)	–0.49 (3.03)

Raw means are shown in brackets. In the case of the Deep and Surface Scales, these are average item means for that scale.

I then ascertained whether the two clusters differentiated between students with different conceptions of Statistics as well as other features of learning. This assisted me in understanding how performance and approach related to other aspects of students' learning, such as willingness to study Statistics. It also enabled me to further check the construct validity of the variable CONCEPT, that is, the conception categories for Statistics.

Table 7.3.5, below, shows the percentages I investigated in the two clusters for all the categorical variables. By reading across the rows of Table 7.3.5 it can be seen what percentage of the students fell into each cluster for the various categories of description.

TABLE 7.3.5

PERCENTAGES OF CATEGORY GROUPS IN TWO CLUSTERS

		CLUSTERS (N=211) 1 (Low Achievers; Surface) (%)	2 (High Achievers; Deep) (%)	N
CHOICE	"YES"	30.5	**69.5**	59
	"NO"	**64**	36	149
CONCEPTION	NO MEANING	**75**	25	8
	PROCESS	**64**	36	53
	MASTERY	**57.5**	42.5	73
	TOOL	42	**58**	59
	THINKING	40	**60**	5
PRIOR LEVEL OF MATHEMATICS	LESS THAN YEAR 12	**65**	35	17
	MATHEMATICS IN SOCIETY	**83**	17	12
	2 UNIT MATHEMATICS	**72.5**	27.5	69
	3 UNIT MATHEMATICS	45	**55**	47
	4 UNIT MATHEMATICS	14	**86**	7
	UNIVERSITY MATHEMATICS	36	**64**	53
PRIOR STATISTICS	NO	**59**	41	144
	*YES	43	**57**	61
AGE	19 YEAR OLDS	**61**	39	105
	21 TO 24	29	**71**	31
	25 AND OVER	**51.5**	48.5	33
GENDER	MALES	40	**60**	53
	FEMALES	**59**	41	157

Percentages are out of N. The majority in each category is shown in bold.

*General Statistical Methods for Arts students or non-university statistics courses.

It is interesting to see which categories of students fell mainly into Cluster 2, the cluster characterised by a high average for achievement on assessments, a relatively high average on the Deep Scale and a relatively low average on the Surface Scale. As Table 7.3.5 shows, nearly 70% of those reporting that they were studying Statistics willingly were in cluster two. Most of the students who conceived of Statistics as applicable to the real world (TOOL, CRITICAL THINKING) were in this cluster. The majority of those who had studied mathematics at one of the two highest levels for their Higher School Certificate, or had taken university mathematics, were in the second cluster as were most of those who had taken a previous course in statistics (distinct from modules in university mathematics courses). The only age group for which the majority was in Cluster 2 was the group aged 21 to 24 years old, suggesting that these students benefited from their maturity and life experiences but were not so far away from school mathematics that they were disadvantaged. In contrast to females, males fell primarily into cluster two.

In summary, the above cluster analysis presents evidence of relationships among students' conceptions of Statistics, their approaches to learning it and the outcomes of their learning. The dichotomy supports the validity of the construct: conceptions of Statistics, as denoted by CONCEPT. The shift in majority from cluster 1 to cluster 2 coincides with the shift from MASTERY to TOOL, that is, from categories associated with conceptions of Statistics as performance in assessments to those which present Statistics as applicable to the real world. The two cluster solution also highlights categories associated with successful learners of Statistics.

7.3.2.2 Four Cluster Solution

The two cluster solution presented above has the advantages of simplicity and parsimony. However, the in-depth investigation on the learning of mature students, carried out in Study One, shows that marks on assessment tasks and approaches to learning Statistics are not related in a simple fashion. Further, a careful examination of the qualitative data for Study Two, namely interview data and students' responses to the open-ended questions in the survey, suggested to me that four clusters would present a more recognisable reality than two. That is, although the data suggested that there were high achievers who expressed educationally desirable approaches to learning Statistics, there also appeared to be those who succeeded in assessment tasks in spite of approaches characterised by a lack of interest or personal meaning and a fragmentation of the material. Also, not all of those who performed poorly in examinations and tests expressed predominantly surface approaches to learning Statistics.

I identified four different profiles of achievement and approaches by clustering on the same variables as for the two cluster solution (CLASS1, EXAM1, CLASS2, EXAM2, DEEP, SURFACE) using the SPSS procedure QUICK CLUSTER (Norusis, 1990, p. 369). In this case I specified the number of clusters as four. As expected, differences between the means for the four groups were considerable on all the clustering variables.

Table 7.3.6 below, summarises this data for the four clusters. They show the standardised means (Z-scores) for final marks in Statistics (MARK) and approaches to learning it (DEEP; SURFACE) for the four clusters.

TABLE 7.3.6

STANDARDISED AND RAW MEANS OF FINAL STATISTICS MARKS AND SCORES ON DEEP AND SURFACE SCALES FOR FOUR CLUSTERS

MEANS N=211	CLUSTER 1 High Achievers; Above Average on Deep Scale (N=47)	CLUSTER 2 High Achievers; Above Average on Surface Scale (N=61)	CLUSTER 3 Low Achievers; Above Average on Deep Scale (N=43)	CLUSTER 4 Low Achievers; Above Average on Surface Scale (N=60)
MARK	**1.03** (77%)	**0.62** (70%)	–0.37 (52%)	–1.1 (37%)
DEEP	**0.98** (2.85)	–0.41 (1.91)	**0.16** (2.30)	–0.4 (1.91)
SURFACE	–1.06 (2.57)	**0.38** (3.75)	–0.50 (3.02)	**0.7** (4.01)

Cluster means which are above the overall average (Z>0) are indicated in bold font.
Raw means are shown in brackets.

Figure 7.3.2 and Figure 7.3.3, below, depict graphically the profiles for the four clusters.

FIGURE 7.3.2

MARKS AND APPROACHES FOR THE TWO HIGHER ACHIEVING CLUSTER GROUPS

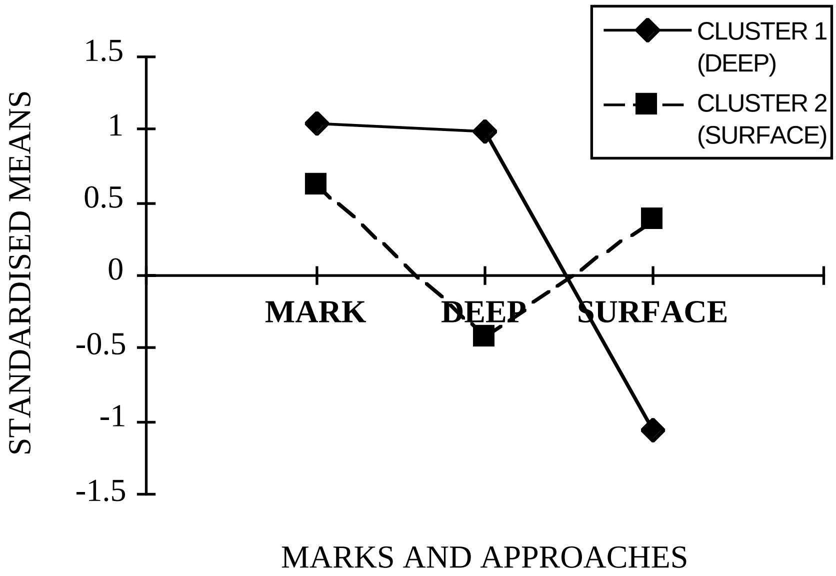
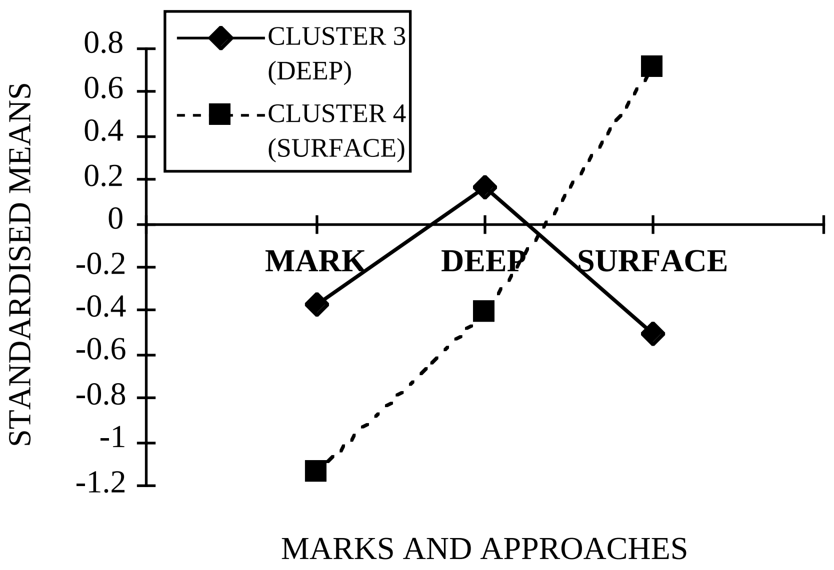


FIGURE 7.3.3

MARKS AND APPROACHES FOR THE TWO LOWER ACHIEVING CLUSTER GROUPS



Most of the males were in the higher achieving clusters, Clusters 2 and 1 (38% and 30%, respectively) while females fell mainly into Clusters 4 and 2 (32.5%, 26%) which have a “high surface” profile.

As can be seen from Figures 7.3.2 and 7.3.3 and Table 7.3.6, above, the four groups had, on average, different attainments in, and approaches to, learning Statistics. Like the two cluster solution presented earlier, the four clusters also differed in their profiles with respect to other variables, such as CONCEPT. These profiles are discussed below and the key points summarised in Tables 7.3.7 and 7.3.8 at the end of this discussion.

The profiles of the first two clusters are particularly interesting. While both these groups of students achieved high marks in Statistics, attaining averages of 77% and 70% respectively, the orientations to learning Statistics characterised by these two clusters were very different.

Cluster 1 is characterised by students who, on average, achieved very high marks on assessments. This is the only cluster for which the average item score on the Deep Scale exceeded that on the Surface Scale. In addition, unlike the other three clusters, most of the students in this group (53%, 25 students) expressed willingness to learn Statistics. The most common, or modal, category for their conceptions was TOOL (49% of them, 23 students) with a further 6% (3 students) in the CRITICAL THINKING category.

The students classified in Cluster 2, as a group, evidently had a facility for learning Statistics, while lacking the motivation or awareness of the subject of their colleagues in Cluster 1. Most (75%, 46) of them reported reluctance to study Statistics. Their modal category of conception was PROCESSES (36%, 22 students), followed by MASTERY (30%, 18 students). These distributions in CHOICE and CONCEPT are consistent with the predominantly surface approach profile of this cluster. In all, they suggest a focus on reproducing aspects of the material for purposes of assessment, rather than a view of Statistics as personally meaningful, relevant and cohesive knowledge.

Clusters three and four performed, on average, at a much lower level than the first two groups, attaining averages of 52% and 37% respectively. Hence, the Cluster 3 students, on average, were less successful in the academic context than the Cluster 2 group, although their approaches to learning Statistics appear to be more educationally desirable than those in Cluster 2. The modal category of conception for this group was TOOL (40%, 17). A further 5% (2) of these students were classified in the CRITICAL THINKING category. However, well under half (40%, 17 students) reported that they would have studied Statistics given a choice.

The profile of the Cluster 4 students is particularly dismal with 93% (56) of the students in this cluster reporting that they would not have studied Statistics given a choice. On average, these students adopted predominantly surface approaches to their learning. Their average item score on the Surface Scale of the Approaches to Learning Statistics Questionnaire was very high: 4.01. The conceptions of 82% (49) of them were classified in the first three categories (NO MEANING, PROCESSES and MASTERY). Most of them (53%, 32 students) perceived Statistics as being about MASTERY of statistical ideas and skills in order to meet assessment demands. Although 13% (8 students) expressed conceptions of Statistics that were classified as TOOL, none of these students reported an intention to actually use this tool.

The following table (Table 7.3.7) summarises the percentages in each cluster for the variables CHOICE (YES or NO) and CONCEPT (NO MEANING, PROCESSES, MASTERY, TOOL and CRITICAL THINKING) described above. The percentages shown are out of the number of cases (N) that is, column percentages and are rounded to whole numbers. Missing data accounts for differences from 100%. I have indicated the modes in each cluster for CONCEPT and CHOICE in bold font.

TABLE 7.3.7

PERCENTAGES OF CHOICE AND CONCEPT CATEGORIES IN FOUR CLUSTERS

		Cluster 1 High Marks; Deep N=47	Cluster 2 High Marks; Surface N=61	Cluster 3 Low Marks; Deep N=43	Cluster 4 Low Marks; Surface N=60
CHOICE	"YES"	**53%**	23%	40%	5%
	"NO"	45%	**75%**	**61%**	**93%**
CONCEPT	NO MEANING		8%	5%	2%
	PROCESSES	9%	**36%**	26%	27%
	MASTERY	28%	30%	23%	**53%**
	*TOOL	**49% (17%)**	18% (3%)	**40% (7%)**	13% (0)
	CRITICAL THINKING	6%		5%	

*The percentages shown in brackets are for a personally useful TOOL.

The four clusters also distinguished between the prior levels of mathematics undertaken by the surveyed students. Table 7.3.8, below, highlights the shifts by showing the modal cluster for each level of the variable PRIOR MATHS. As can be seen from this table, the modal cluster for the groups of students with lower backgrounds in mathematics (2 Unit Mathematics or less) was Cluster 4 (low achievement, above average on Surface Scale). The modal cluster shifted to Cluster 2 (high achievement, above average on Surface Scale) for the students who had studied 3 Unit Mathematics for their Higher School Certificate. Encouragingly, for those students who had taken the highest level of mathematics at school (4 Unit Mathematics) or had studied mathematics at university, the most common cluster was Cluster 1 (high achievement, above average on Deep Scale).

TABLE 7.3.8

MODAL CLUSTER FOR PRIOR LEVELS OF MATHEMATICS

PRIOR MATHS	Cluster 1 High Marks; Deep	Cluster 2 High Marks; Surface	Cluster 3 Low Marks; Deep	Cluster 4 Low Marks; Surface	N
Less Than Year 12				**47%**	17
Maths In Society				**58%**	12
2 Unit Maths				**44%**	69
3 Unit Maths		**38%**			47
4 Unit Maths	**57%**				7
University Maths	**40%**				53

The percentages shown are out of the number of cases (N) that is, row percentages.
Percentages are rounded to whole numbers.

Finally, there was a relation between the two cluster solution and the four cluster solution. The 97 students who were in the Cluster 2 (high achievers) for the two cluster solution were almost equally divided into Clusters 1 and 2 in the four cluster solution (49% and 45%, respectively). Six percent were in Cluster 3 and none in Cluster 4.

In summary, the four cluster solution highlights differences in orientations to learning Statistics and performance on assessments with greater depth and complexity than the two cluster solution. The directions and shifts of the categorical variables such as CHOICE and CONCEPT are in the predicted directions, thus enhancing the validity of the analysis.

7.3.2.3 Vignettes From Student Interviews

The profiles described above are of clusters, not individuals. Hence any individual learner may fit some but not necessarily all the characteristics of the cluster group into which she or he has been placed. The following excerpts are from interviews with students from each of the four clusters. These illuminate the profiles described, yet present features of learning Statistics which are highly individual.

Tilly and Ben were high achieving students. Tilly (Cluster 1) achieved a final mark of 87.5% on Statistics, while Ben (Cluster 2) attained 95%. The written responses of these two students to the survey Question 2a indicated that they adopted similar strategies of reading lecture notes and doing examples. The intentions of the students were, however, quite different. Tilly wrote for Question 2b that she was trying to achieve:

> *a stable & satisfactory understanding of statistics and the ability to handle data confidently*.

Ben, however, wrote that his intention was to:

> *Get the right answers!*

Their comments in the interviews substantiate these different approaches.

TILLY (Cluster 1)

> When I'm trying to summarise my lecture notes I try to integrate all the information I have on each set topic. ... And understand that and therefore know how to apply it. ... What we're doing this semester is a lot more real statistics, how you really apply statistics to what you're doing. ... Obviously on a higher level there's probably a lot more to it. I'll learn that in third year. But so far I think that's how psychologists would go about testing and researching these things. I'm interested in that sort of area — like experimental research, that sort of stuff. ... I want to learn it because I'm going to need the knowledge. And also — in a lot of ways it overcomes my frustration I had with maths last year. I looked at some of the work I thought last year was so difficult — and it's just basic to what we're doing now. So it's a triumph, almost, to have overcome that big barrier to statistics that I had built up last year.

Tilly evidently saw Statistics as a tool and one, furthermore that she intended to put to good use. Ben's focus on the other hand, was mainly on statistical processes — getting the right answer.

BEN (Cluster 2)

> It doesn't so much interest me, but it's easy going. You don't have to muck 'round doing reports and stuff. You can just learn it. And it's

> sort of half relevant to what I'm doing, and that's fine. ... It doesn't bother me a great deal if I don't understand, say, the exact theory behind different distributions and stuff like that. It doesn't really concern me a great deal. As long as I understand the basics and be able to just get through the questions.

Tessa (Cluster 3) despite taking the highest level of mathematics at school, achieved only 47.5% for Statistics. This was mainly due to her poor performance in the multiple choice examination in first semester, where she attained only 20%. Her survey responses to the third open-ended question led me to categorise her conception of Statistics in the highest category — CRITICAL THINKING. This was consistent with a relatively high score on the Deep scale of the ALSQ (Z=2.67). In her survey she indicated a high level of engagement with learning Statistics and insight into statistical knowledge. She wrote the following responses to the open-ended questions:

Q1: *Yes. Statistics is required for almost every field of study and is a very useful form of comprehensive analysis.*

Q2a: *From GSM (General Statistical Methods) notes, text books & lectures & tutorials. Statistics is structured mathematics & should be considered as a friend to psychology, ∴ I should enjoy learning its various methods to my advantage.*

Q2b: *A comprehensive understanding of everything for use in the *Ψ department.*

Q3: *Stats is about methodology which is used as a comprehensive form of analysis to interpret and test theories & correlations psychologists create. Substantiated method.*

Tessa's interview responses confirmed that she was an exceptional student.

TESSA (Cluster 3)

> It's very interesting — how statistics moulds itself into psychology. Right now I think psychology's trying to become a science because of the emphasis that people put on science being the main area of

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* Abbreviation for psychology

> knowledge. The way statistics moulds itself into psychology kinda gives psychology a basis. Like — how would you put it — like raw facts that can be analysed scientifically, I guess. In 4 Unit Maths there wasn't that much application to things in real life. A lot of it was just formula based, following the formulas, plugging in the numbers. With statistics, however, you've got an aim. In a real life situation, in society — statistics is like a tool to analyse whatever happens when you do experiments. ... It's helped me think more logically. Like inductive reasoning. It's a lot like inductive reasoning. You come up with a hypothesis and you have to follow through in order to get an answer. ... I guess that's one of the main reasons I chose psychology and philosophy. I wanted a broader view of life. Science and maths in high school was more a regurgitation of theories. I just thought that in psychology and philosophy I might be able to contribute some new ideas.

Hence, despite her low mark in Statistics, Tessa seemed to have orientations to learning Statistics that most educators would find highly commendable. Her survey and interview responses indicated that she was exceptionally motivated to learn Statistics. She evidently conceived of Statistics as a way of understanding experimental data and interpreting information from the world around her in a scientific way. Tessa's approach to learning Statistics seemed to have all the hallmarks of the deep approach (Biggs, 1987) — interest, personal engagement and relational understanding.

Narelle was classified into Cluster 4. She had studied General Statistical Methods in her first year of university, but attained 50% for Statistics, well below the 58% average for the surveyed students. Her score on the Surface Scale of the ALSQ was almost one standard deviation above the mean (Z=0.9) while on the deep scale she was well below average (Z score on DEEP: –0.65). Her survey responses to Question 2a and 2b were brief, indicating a lack of interest in the topic:

Q2a) *did exercises*
Q2b) *to pass the year.*

In her interview, Narelle indicated a preoccupation with mechanical procedures, verifying our classification of her conception category as PROCESSES. Her lack of relational understanding meant that her previous knowledge of statistics was confusing to her, rather than helpful. An excerpt follows.

> I usually come home and have a look at what we've done in class and hope I understand it. If I don't then I'll perhaps contact my tutor, which I've only done once, or just keep doing the exercises until I work out what's going on. ... I want to be able to do it automatically rather than it be such a difficult process. ... I'd find what I need out of the problem, the mean and whatever, and then work through that — rather than read so much into the problem; what's going on with the rats or whatever. ... I'm trying to get the relevant information from the problem without being distracted by so much to think about, like the whole experiment. ... I found it just a little bit confusing because sometimes we have been doing the same sort of problem (as General Statistical Methods last year) but doing it round a different way. I found that a little bit confusing. I mean, if I'm confused then those that didn't do GSM last year must be really confused.
>
> I don't enjoy it particularly. I enjoy it once I get an answer out I guess, but the working out is just not my thing. I'm not a very mathematical person.

Narelle, it seems, endured, rather than experienced, learning Statistics.

7.4 SUMMARY AND CONCLUSION

The findings of this study support the activity theory position that the reflections of the mind, goals, or intentions, and actions are linked and are inseparable from the arena in which they are formed and which they transform (Leont'ev, 1981; Vygotsky, 1978; Wertsch, 1981). In this chapter, I first showed links between students' conceptions of Statistics, denoted by categories of conception, and their approaches to learning Statistics, as indicated by scores on the Approaches to Learning Statistics Questionnaire (ALSQ). The analysis showed a linear relationship between the conception categories and scores on the ALSQ. That is, average scores on the Deep Scale of the ALSQ increased with each increase in conception category and, with the exception of the NO MEANING group, average scores on the Surface Scale of the ALSQ decreased with each increase in conception category. The low scores of the NO MEANING students on both scales of the ALSQ suggests that for diverse reasons there was a lack of engagement by these students with the learning task.

The association between ways of conceptualising Statistics and ways of approaching learning it (intentions and strategies) was extended to a more comprehensive interpretation of the relationships among a number of variables concerning students' orientations to learning Statistics and the outcomes of their actions. Factor analysis (excluding the NO MEANING students) suggested that underlying factors spanned the network of variables. One major factor linked variables concerned with students' performances on the four assessment tasks. A second, separate, and more interesting factor linked variables which were concerned with students' orientations to learning Statistics. This showed positive associations among variables indicating willingness to learn Statistics, categories of conception (for four categories) scores on the Deep Scale of the ALSQ and level of prior mathematics studied. Surface Scale scores loaded negatively on this factor. Consistent with previous analysis, a positive link between Surface Scale scores and females was found, while age was negatively associated with levels of prior mathematics.

Cluster analysis is a powerful, though little used, method in education research (Ainley, 1993). Previous research conducted by colleagues and myself (Crawford et al, 1995; 1998) suggests that this technique is appropriate for illuminating complex data. I used cluster analysis to tease apart the relationship between students' approaches to learning Statistics and their achievements in tests and examinations, as this was not revealed by the factor analysis. Cluster analysis, as well as triangulating the ways of understanding the structure of the data, shifts the emphasis from positive and negative loadings of variables on factors to groups of students.

Cluster analyses into two clusters and then into four clusters provided different perspectives on the data. In Chapter Six, two obvious "clusters" or groups emerged from the analyses — the "YES" students and the "NO" students. In this chapter, clustering was done on variables relating to performance and approaches. The two and four cluster solutions that emerged from these cluster analyses provided a deeper alternative to simply grouping students into those studying Statistics willingly and those studying it unwillingly.

The cluster analysis dividing students into two clusters separated students into a large and a small group (Cluster 1 and Cluster 2). The smaller group, Cluster 2, achieved high average marks in tests and examinations, had a comparatively high mean on the Deep Scale of the ALSQ and a low mean on the Surface Scale, relative to the overall averages on these scales, while the converse was true for the larger group (Cluster 1). The majority of the YES students were in the higher achieving Cluster 2, as was the majority of the students whose conceptions were classified in the "higher" conception categories: TOOL or CRITICAL THINKING. On the other hand, the majority of the "NO" students were in Cluster 1. Consistent with the Cluster 1 profile, most of the students categorised in the "lower" conception categories (NO MEANING, PROCESSES and MASTERY) were grouped in this cluster. These results triangulate previous analyses and add to the construct validity of the variables investigated. In particular, shifts in the proportions of students from Cluster 1 to Cluster 2, as the categories of the variable CONCEPT shift from MASTERY to TOOL, are consistent with qualitative interpretations of this split.

In further cluster analysis, I divided the students into four groups. The profiles of these clusters indicate markedly different orientations to and outcomes of learning Statistics. This analysis suggests that, unfortunately, in three of these clusters, the majority of the students were unwilling to learn Statistics, conceived of the subject mainly in terms of accumulating knowledge for assessment purposes and adopted mainly surface approaches to learning it. While for one of these groups, Cluster 2, students did well in tests and examinations, on average, it seems unlikely that many will transfer their knowledge to other environments. For a small group of able students in Cluster 1, however, the picture is far more satisfactory. In addition to achieving high marks, these students were, on the whole, motivated to learn Statistics, showed an awareness of the applications of the subject beyond the classroom walls and, on average, adopted relatively deep approaches to learning it.

Some students, such as Tessa in Cluster 3, showed a high awareness about Statistics and pursued deep approaches to learning it yet did not achieve high marks in the conventional tests and examinations. Students such as these present a great challenge to educators. Biggs (1987, p. 103) suggests that students with a predominantly deep or internal approach are:

> interested in following their own interests, relating to their own previous experience, generating their own examples, and following up their own leads.

Such an approach does not necessarily lead to the fulfilment of institutional goals, or to high academic attainment, although it may satisfy the student's own goals.

This chapter answered the final sub-principal research question of Study Two by describing the relationships among the variables in this study. These included demographic variables, the students' willingness or reluctance to study Statistics, the students' conceptions of Statistics, their approaches to learning Statistics and their assessment results. The findings present strong evidence of relationships among these variables. It also shows that students in the same class have strikingly different experiences of learning Statistics.

CHAPTER EIGHT

ADDING TO THE CONTEXT: TWO TEACHERS' PERCEPTIONS OF LEARNING AND TEACHING STATISTICS

8.1 INTRODUCTION

The theoretical framework I have developed in this thesis emphasises the mutual shaping of the learner and the setting. Teachers are an important part of this organisational network. They influence the perceptions and actions of the students. In turn, teachers' perceptions and behaviour are formed by their own experiences, both their past experiences and their current awareness about the students and setting. Teachers' actions are constrained by the conditions surrounding them. Hence part of my understanding of student learning relates to interpreting the activities of the teachers of Statistics, as they manage their classrooms.

Chapters five, six and seven indicated the diversity in students' appraisals of learning Statistics, conceptions of it and approaches to learning it. Similarly, there is diversity among the perspectives of the educators responsible for moulding the course. The following extracts from transcribed interviews show how two teachers perceived the setting for teaching and learning Statistics. Both these educators had taught Statistics for some years. I shall denote them by Cathy and Wendy. Each was interviewed separately and the interviews were relatively unstructured. I asked a few "seed" questions such as:

> *What do you hope students will gain from the second year statistics component of Psychology?*

A guide to my questions is reproduced in Appendix I. However, as far as possible, I allowed the teachers to tell me about their perceptions, with minimal interference. Similar themes emerged from the two interviews and I shall report these together for comparison.

8.2 INTERVIEWS WITH WENDY AND CATHY

Both Cathy and Wendy had clear ideas of the purpose of including Statistics in Psychology II.

Cathy saw Statistics as a tool for research as well as a way for students to critically assess information. She said:

> First of all, in reading the literature, understanding what other people have done in their experiments and secondly to help them if they carry out their own research as well, to understand how we have to make sense of numbers and what we do with statistics. To help us make sense of it.

She hoped that what students would get out of the Statistics course was:

> Well, just an understanding of the place of statistical procedures within the overall research approach in Psychology. So, not to see it as something completely separate but to see how to use it as an aid to systematic thinking and detecting effects amongst all the noise, that sort of thing.

Wendy related Statistics to further study but also drew on her own experiences to explain the place of Statistics in students' ongoing lives. She said:

> I see it as giving little tastes of what you can do. Building up perhaps to the third year course which is much more focused on multiple comparisons, using your F's, using your contrast analyses.
>
> The purpose in any course is to lay the ground work for:
>
> A) those who want to go on further in your traditional, academic research oriented stuff and B) for those who don't want to go on further but are basically getting a degree so that they can then move into a large company. To basically lay the framework so that when things do come across their desk they can understand it.

> It sounds trite but I’ve got friends who have done that — moved into banking or market research or whatever, and are having troubles in terms of colleagues who are not understanding:
>
> ‘What’s an average?’
>
> ‘What’s a distribution?’
>
> Even if the students don’t remember how to do a chi-squared test, they’ll know what a population is. And what the point is — we’re trying to tell whether this is having an effect.

I asked Cathy and Wendy how they tried to achieve these educational aims for Statistics in their teaching. Their responses showed that they both regarded concrete examples as of prime importance in helping students understand the concepts. Cathy drew on text books for her source of examples while Wendy evidently tried to motivate her students by linking her examples to students’ everyday lives.

Cathy:

> I suppose it depends which topic we’re talking about. In general, I try and do it with examples, instead of doing it in the abstract. I relate it to actual examples of when these problems might arise and how we’re going to cope with these sorts of numbers. What we’re going to do with them — and understand why they’re going this way or that way.
>
> I waste hours thinking up the examples. That’s probably the better part of the time that I spend on it. I go through the books. Yes, I think of the examples that might typify the sort of situation.

Wendy:

> Well the course itself is structured in terms of the tutorials. There are set materials to get through. What I try to do is give them an overall feeling for what they’re going to do. For example with chi-square tests. Not all data is continuous. Sometimes it’s:
>
> ‘Do you like Pepsi, or do you prefer Coke?’

> And that sort of data is just as interesting. However, you treat it differently because you can't build up a number line. It's just: 'Yes' or 'No', or maybe you've got more categories.
>
> Give them an overview like that. Give them an overall spiel about when would you use it. Try and come up with examples that are interesting. For example, to make multiple regression interesting you can try and predict who's going to win the Melbourne cup. And change the equation:
>
> 'This is a new jockey, this is his weight, this variable is: Has the horse won the Caulfield?'.
>
> And it's quite amazing then how you'll get the people at the back:
>
> 'Oh right!'.
>
> (Much laughter). And then move onto the:
>
> 'Alright in front of you, here, we have a series of problems. Alright what's next?'
>
> Question and answer time.

The above comments of the two teachers indicate that each had a different sense of what it means to learn Statistics. This difference emerged more clearly from their reports about how a student's understanding of Statistics was measured.

Cathy:

> I think our best feedback comes from the tests rather than the exams. The exams are multiple-choice and I don't really think that multiple-choice exams are a wonderful method of assessment. They're just essential for financial reasons. I think it's in the test that you get the most feedback about what they're understanding and what they're not understanding. What they can do with it. Whether they can draw appropriate conclusions. You see a lot of the little things that they're not understanding, by looking at how they perform in tests.
>
> Well, things like in hypothesis testing — just whether they can — given a critical value, an observed value, can they work out what they

> had to do with it? And then what conclusion they can draw having decided to accept or reject the null hypothesis. That's a funny whole cycle that they can often be confused about. Three different parts. Once you can force them to write out their answers, you can see if they're understanding it. And if they can apply formulae. Which is tedious and will probably become less and less of a necessity as courses become more computerised. So the emphasis will become more on understanding output of the procedure I think.

From this it appears that Cathy's emphasis was on skills and procedures, although she acknowledged that the time for such procedural learning was past. Wendy appeared to be more concerned with the future relevance of the concepts being learned.

Wendy:

> I think with stats, a lot of it is rote learning and it is very dull — until you actually get to do it yourself. I was no brilliant stats brain at uni. but once I started working it had a point. So that's what I try and do.
>
> 'Okay, well, what's the point? What is the point of all this?'
>
> Obviously, one point is that they want to pass the exam and if they're happy just to do that — fine.
>
> 'But the rest of you think beyond the exam. This is the point'.
>
> So that's what I try to do. I always try to bring it back to something tangible. Otherwise it does get to be:
>
> 'Okay, just write down the answers and we'll learn it later'.

The above comments depict these two teachers' different conceptions of learning. They also indicate their different conceptions of Statistics. Cathy evidently put more emphasis on the procedures and mathematical algorithms as an end product of learning — as the form of statistical knowledge — while Wendy indicated that rote learning was a stepping stone to conceptual understanding. These differing evaluations of the procedural part of Statistics versus the interpretative component were demonstrated in the following extracts from their interviews comparing Science and Arts students.

Cathy reported that she had taught tutorial groups which, because of timetable constrictions, were predominantly made up of Science students.

> You tend to get concentrations of science students in certain tutorials because of timetable constraints and they just stand out. They're so different to the Arts students because they're not scared of formulae. They can deal with it. I was astounded with this group I had last semester. They had it. They could do it. Then I went straight into a predominantly Arts tutorial group. It was a whole different story. It was just much harder for them. That was the main, obvious, difference.

I asked whether there was a difference in the students' interest in Statistics. Cathy replied:

> More the competence.

Cathy seemed to be suggesting that students who were good at the algebraic manipulations and algorithms were good at Statistics. Wendy, while agreeing that the Science students were better at this aspect, did not see applying formulae as the most important aspect of mastering Statistics.

Wendy:

> Very definite differences. The Arts, with 'Arts' in inverted commas — your heavily, language based people, tend to get a lot more into analysis at the language level. But your general Arts students will tend to be fazed by the sigma, etc. etc. etc., and basically a bit number phobic at the beginning. However, they're very good at interpreting results. They're good at telling you what's actually going on. Whereas the Science students tend not to worry at all. It doesn't faze them — all the Greek letters, etc. etc. or the subscripts or the algebra, but they're not very good at drawing conclusions. I think that in your traditional physical sciences — what's there is there. You don't have to interpret it. You just report:
>
> 'We rejected', or 'This is from a different sample'. Full stop.
>
> Well what does that mean? So they tend to balance out each other.

Cathy and Wendy's comments are particularly interesting in view of Ben's assessment of Statistics. (See the excerpt from the interview with Ben, section 7.3.2.3.) Ben was not a Science student but his responses indicate a focus on and a facility with the procedural part of Statistics and he did, indeed, score very high marks in Statistics. This facility with statistical techniques is in accord with Cathy's interpretation of competence, and, judging by his marks, with the objectives of the Statistics course.

The institutional setting shapes educator's activities as much as it does students' perceptions and actions. Cathy and Wendy agreed that a shortage of teaching time for Statistics was a major constraint.

Cathy:

> Well, I think in our course students are disadvantaged. In other courses, apparently, they have a lot more time to spend on statistics. Like at third year level, they have, I know, at another university, two hours a week of lectures, an hour of tutorials and an hour using computers. They have a different structure to their degree so they can manage their time. Our students are asked to absorb a lot in a short space of time. They do reasonably well at it.

I asked whether Cathy felt the Statistics course could be improved by having more time spent on it. She replied:

> Yes, but I don't see where the time is coming from. It's an impossible limitation.

Wendy:

> I think with the second year course there are some things where you could go. I think it could cover more ground than it does. Not in terms of the time we have now. But I think we do need two lectures a week and two hour tutorials. You don't get enough time. You don't get enough time to sit down ... . You've got thirty minds in a classroom and everyone's going in different directions. Now if you're

> lucky, fifteen of them will be with you. But of course it's hard when you're up there.

In addition to lack of time, Wendy felt the lack of opportunity for students to apply statistics was a further constraint which hindered them from seeing statistics as useful and relevant to the field of psychology. She saw this as partly due to students' insufficient statistical knowledge at that stage of the psychology course. She said:

> Stats to me was just something you did — until I was actually working. And then it became relevant because it was my stuff. It was my data. What I would like to see is an integration, perhaps, with other areas — social psychology, learning, etc. etc. In that you can do an experiment and apply your own statistics. Unfortunately, my experience, having taught 'Learning' in second and third year, is that, of course, experiments that you run are too complicated for the stats that they know. But I think that you could present them with a data set that could be analysed. Chi square tests are very useful. I think that's where it needs to be tied in, rather than having very discrete parts. I think in second year every unit is very separate:
>
> 'Here's your Statistics. And here's Social Psychology. And here's the statistics we've done for you'.
>
> It is a very structured course. Very structured tutorials. Getting back to the time issue — you tend to overrun the time. Having taught it for a few years, I now know where time can be made up. What you can reasonably expect them to understand on their own.

Cathy concurred with Wendy's view that a lack of statistical knowledge constrained students' understanding of it's application:

> I think that probably they don't have a clear idea (of statistics) yet. They haven't done any research yet and a lot of them aren't even reading the publications in the literature. They're just reading the general text books or whatever, so I think they're not really yet able to have an overview of what it's all about. How they might ever be able to use it.

> Usually they haven't got a clue what to do anyhow, but usually any analyses that come up in other areas of the course are more complicated then anything they've covered yet in their actual Statistics course. It's hard to coordinate between members of the department.

Perhaps the most important factors around which students organise their activities are the tests and examinations. Wendy explained her ideas on the part played by assessments and how students respond to them:

> My theory is — people only work with a carrot or a big stick. And I think the tests act as a stick. But you can take notes in (to the class tests) and I also stress to them:
>
> 'For an open book test, you're taking your notes in as a dictionary. There's no use knowing every statistical formula in the world when you can look it up in real life'.
>
> That was the philosophy that my statistics lecturer had taught me. And that my statistics has always had. You know you might not be able to spell a word, but you do know where to get the dictionary from.
>
> The first test — they walk in with a lot more than just their notes. The second test — 20% of them have made a summary page. By the last test of the semester — 90% of them have a summary page that is appropriate. And I also stress things to write down.
>
> 'Write down the null hypothesis. Because then if you accept or reject it, you know what you're accepting or rejecting. Your life's so much easier'.
>
> I find, too, that a lot of people can't do exams. I think the exam structure, here, where you tend to have one large exam with various subjects within it — doesn't give you enough practice.

The two educators I interviewed had different perspectives on the multiple-choice examinations. Cathy saw multiple-choice examinations as valid for assessing students' knowledge. She said this.

> Even though the exam is closed-book, it's not a test of memory, of formulae. The formulae are in there if they need them. So it's not a completely unfair method of assessment. The fact that it's closed-book is not by itself a major problem because closed-book tests are only a problem if they're forced to memorise lists of stupid things. For example, school students have to. But they don't have to because they're given the formulae.

Wendy did not defend multiple-choice examinations. In a more pragmatic approach to this type of assessment she explicitly outlined techniques for coping with them — what Norman (Study One, section 5.2.4) referred to as 'tricks'.

> The multiple-choice exams ... . Another exam technique the students don't realise is:
>
> 'Okay, all the equations you need to know might not be on the front page. But they're probably very cleverly embedded in some of the other questions. Go back and have a look. If it's there, put a ring around it. The exam paper is not the Holy Grail. We're not going to bronze your exam papers and keep them. You can write on it. You can underline'.
>
> A lot of students don't. So I think for those students that are edgy about stats, and there's a lot of exam anxiety around, especially with numbers — I find that is something very concrete that they can grab onto and it's almost, in a way, allaying anxiety in one area.
>
> Also, the other strategy that I stress is that in the multiple-choice exam you never look for the answer. You make the answer up in your mind and then you look for it.

Wendy's rationale for teaching examination techniques was that this was something concrete for the students. She said:

> And it gets results.
>
> 'Oh my mark's gone up by four!'
>
> Whereas if you're going to stress the deeper understanding you don't get the immediate feedback. People go:

> ‘Oh well, I still don’t understand it’.

A considerable part of teaching concerns how teachers manage their classes. Cathy simply said that she ensured that students stayed awake in her classes. Wendy, however, explained how she ensured that students were participating in her classes and were following her explanations.

> I’m not one just to stand at the board and write. I tend to roam around the classroom. Basically to see what’s going on. You can tell whether people are lost that way. They’re staring at the blank page in front of them or they’re doodling or they’re staring at the window. And if you ask someone: ‘Do you understand?’, they’re more likely to answer you if you’re right there. Rather than if you’re five, six — even, in the larger rooms, eight rows from them. They’re at the back. They’re a dot. You’re a dot to them. But if you’re there:
>
> ‘Okay, do you understand?’
>
> ‘Mmm’.
>
> ‘How come you’re not writing it down? How come that’s wrong on your page?’
>
> ‘Oh well. I don’t understand this.’
>
> And I learn their names and call their names. That, I think, is important. Because you will get the peanut gallery up the back. And if they know you know their names ... . You can say:
>
> ‘Okay, what’s the next step, Nick? Ah right, you weren’t listening. Okay pay attention’.
>
> Learning the names goes very well. I was amazed at how many people expressed surprise that I knew their names. Generally the reactions that I get are very positive. I always have full classes. I’m very popular in that I think I do the ‘Ha, Ha’. And the roaming around keeps them a bit more awake than tutors who are just as good but have a different style.

Vygotsky’s theories give prominence to direct, personal interaction (Vygotsky, 1962). Wendy’s account, above, testifies to the importance of this. She went on to affirm the activity theory emphasis (Leont'ev, 1981) on students actively engaging in their learning, rather than passively accumulating "knowledge".

> I'm also finding, too, with the students that you're getting — I don't know if it's HECS (Higher Education Contribution Scheme) — that they're actually paying for it. But you're getting very much a school mentality:
>
> 'I want to be taught'.
>
> My philosophy is: I don't hand out worked examples. They're on my door. So you tend to get a lot more people outside your door with worked answers. Which is the point. The point is not to just get sheets and sheets and sheets. It's like a safety blanket for these kids. The more notes they have the better, of course, they feel.

Wendy laughingly acknowledged that:

> That's my own history at uni. That's the way I went through. But from the other side of the fence, I'm just not going to tolerate that sort of behaviour.

Wendy was explicit in stating her aims to students:

> I tend to go in at the beginning of every semester and introduce myself and say:
>
> 'Alright, we're going to do this in various ways. One way is to get you through the exams. One aim of mine is — if you are interested — to go further on with it. Another aim of mine is to get every single one of you up to a level where, alright on paper, you might not be brilliant, but you feel competent enough to sit down and understand other things that you might be reading'.

Wendy's aim, expressed above, that students should feel confident enough to use their statistics, irrespective of how it looked "on paper", resonates with Sandra's evaluation (in Study One, section 5.2.5) reproduced below.

Sandra :

> I'm not going to let the exam mark dictate to me my knowledge. Because I knew I had a better grasp at the end of the year and I really felt that if I was doing experimental work I could work out what to do with my stats.

Cathy and Wendy were committed, enthusiastic teachers of Statistics. Cathy described her perceptions of the rewards of teaching Statistics as follows.

> I love it. I love teaching Statistics. The rest of psychology is so waffly in many ways. I feel Statistics is just less so. Every year I have at least one student come up to me — I had one this week — and say:
>
> 'I don't know how you can bear to make a career out of teaching Statistics'.
>
> But I really enjoy teaching it and I enjoy the gratification when they understand it. You see that they've gone from not understanding it to understanding and their own satisfaction in mastering it.

Wendy related to her students by recalling her own experiences of learning statistics:

> The thing that I have to remember is how I learned it. And before you go into a tutorial you've got to think:
>
> 'Okay, where are people going to go wrong?'
>
> And second guess the points at which they will. Spend a lot of time clarifying it.
>
> I think what's changed is my perception of how useful it is. I think that I would have had a much easier time in fourth year and in my initial working years if I had learned it. And to me now, I did waste a lot of time. Sure I got through. But it is a very easy subject. And all these people who are breaking their necks to get into fewer and fewer Honours places:
>
> 'You have a subject which is not hard'.

> And I always point out when they say: 'Oh I can't learn this'.
>
> 'You can learn it. The point is whether or not you will'.
>
> I think it's a very easy way for these people to achieve their goals. But of course it's all mixed up in this aura of: 'Oh it's maths.'
>
> And maths in school to me was always very dull.

Hence to Wendy, in accord with the view of activity theorists (Leont'ev, 1981) goals are the primary elements in determining how and what learning takes place.

Wendy clearly empathised with her students' lack of enthralment with Statistics. However, her own experience of using statistics enabled her to see it's potential for enhancing the perspectives of students in their future lives.

> What do they take away from the second year Statistics course? I mean the formulas are gone by Xmas. Right? What I think stays is the concept of the underlying populations — the difference between looking different and being significantly different. But I'm not sure you can measure that. I think where that comes out is in their third year. When they go and read papers and do have a feel for an experimental hypothesis and a null hypothesis. Unfortunately we can't tap into that until further down the track. The students can't tap into it until they sit down and have that 'Aha!' experience. The realisation that:
>
> 'I do know what they're talking about!'.

The theoretical framework I have developed highlights the need to recognise that the classroom is not just a place where instruction is received, but a social structure in which students' and teachers' actions form. The interviews with Wendy and Cathy provide some insights into this constitution.

8.3 CONCLUSION

In this project, students reported a range of conceptions of Statistics. The seeds of many of these conceptions, such as those categorised as PROCESSES, MASTERY or a TOOL, can be seen in the descriptions given by the two members of the teaching staff I interviewed. Teachers' views and perceptions are very important elements of students' learning. It is to their lecturers and tutors that students look for guidance in interpreting their tasks.

CHAPTER NINE

SYNTHESISING THE STUDIES

9.1 INTRODUCTION

Many important results were found in investigating the principal research question:

> What are students' orientations to learning Statistics ?

These findings answered specific sub-principal research questions in chapters five, six and seven, and were summarised at the ends of those chapters. In this chapter I focus on relating the conclusions of the two studies. I synthesise the studies by explaining how activity theory underpins the significance of these findings. I explicate the idea of the cultural dimensions surrounding students' activities, drawing on the explanations of Hofstede (1991).

9.1.1 Chapter Preview

Firstly, in section 9.1.2, I summarise three powerful and inter-related conclusions of the investigation that emerged from the two studies. In section 9.2, I interpret students' orientations to learning Statistics in terms of my theoretical framework. In section 9.2.1, I focus on students' conceptions of Statistics. These conceptions highlight Leont'ev's (1978) differentiation between collective meaning and personal sense. I then discuss, in section 9.2.2, how learning Statistics incorporates both actions and operations in Leont'ev's (1981) terms and how these fit with notions about approaches to learning (for example, Marton, 1988). I analyse the ways in which orientations to learning Statistics are underpinned by dimensions of culture in the next section (9.2.3). Five different dimensions operating in cultural systems (Hofstede, 1991) are examined here to view how the participants in my studies positioned themselves with respect to the learning task. I conclude by discussing a systemic approach to understanding students' learning in context in section 9.2.4.

9.1.2 Overview Of Key Findings

Study One and Study Two furnished evidence in different ways for the following major conclusions, each of which includes the previous conclusion(s).

- Students reported a range of conceptions of Statistics. These conceptions were connected to the students, the context of their learning and the subject matter.
- Students' orientations to learning Statistics, the ways they positioned themselves with respect to the learning task, encompassed in a systemic way their previous experiences, motivational aspects, conceptions of Statistics, and approaches to learning it within a social and cultural milieu.
- The studies present evidence, in terms of qualitative and quantitative analyses, for relationships among students' orientations to learning Statistics and outcomes of their learning. These reflect individual diversity, institutional practices and the broader sociocultural setting.

9.2 STUDENTS' ORIENTATIONS TO LEARNING STATISTICS — AN ACTIVITY THEORY APPROACH

9.2.1 An Activity View Of Students' Conceptions Of Statistics

In Study One, I explored the experiences of five mature students. The reports of the five students indicated diverse attitudes and conceptions and a range of cognitive and practical actions taken by these students as they sought to meet their needs or reach their goals. For example, Sandra described these effortful and purposeful actions and interactions for building up a conception of Statistics as meaningful and cohesive knowledge. (Quote reproduced from section 5.2.4.)

> I worked through my lecture notes at the same time as the lecturer did. I just wanted to get a broad brush stroke, a picture and then more detail with the tuts. I went to three tutorials, one at the beginning of the week, one in the middle and one at the end. Each time it became a little clearer. By the third time I was feeling on top of it. And then I was coming here (to the Centre) twice a week as well. And I was working with Norman and Alice and my husband as well. We worked through examples for hours, our 'tut' sheets, to learn how typical these things are — to understand.

The conditions under which the students' goals were formed, and the students' histories, against which their intentions and actions must be interpreted, are critical to understanding learning Statistics as an activity, in Leont'ev's (1981) terms. To most of the participants of Study One, the arena of learning Statistics was, very early in the year, identified as a school type setting. Some of them expected that Statistics, like their mathematics at school, would be incomprehensible and esoteric knowledge. As Hettie put it:

> what scientists, astrophysicists do, not what I could do.

In contrast to their awareness concerning school mathematics or Statistics, all the students in Study One conceived of real life statistics as something manageable and useful. For example, Alice felt confident enough to challenge a telephone interviewer about the surveying methods he used. However, in the university context, she expressed her frustration at her inability to grasp Statistics. Ernest enjoyed using statistics to pit his wits against those of bookmakers. However, he described institutional conditions, such as a shortage of time to appropriate the ideas and a overloaded curriculum, which constrained his understanding of Statistics.

I have concluded from this that the ways in which students think about Statistics cannot be separated from their actions taken to learn it, nor from the arena of their actions. Drawing on the ideas of Vygotsky (1962, 1978) and Leont'ev (1969, 1978, 1981) as discussed in chapters two and three, I assert that awareness and reflection are not psychological givens but are socially constituted. Students' conceptions of Statistics are produced in social interaction and realised in actions.

In Study Two, the phenomenographic method enabled me to build up an structured set of categories for students' conceptions of Statistics. These ranged from notions of Statistics as having NO MEANING, through ideas of its being about PROCESSES or ALGORITHMS, then MASTERY of concepts and skills, to a TOOL for use in life and, finally, a way of CRITICAL THINKING. The last two categories illustrate an important distinction made by Vygotsky between tools and signs. The tool, according to Vygotsky (1978, p. 55):

> must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing over, nature.

The sign, on the other hand is a metaphorical tool. It is an internal regulator, or in Vygotsky's words:

> a means of internal activity aimed at mastering oneself; the sign is internally oriented (Vygotsky, 1978, p. 55).

Students who perceived Statistics as a TOOL regarded it in terms of getting results in real life, for example in research. Responses classified in the CRITICAL THINKING category, as well as expressing Statistics as being about practical applications, denoted Statistics in terms of learning to master oneself, or, as one student wrote in her survey:

> ... to be in control of figures not have them control me.

Hence responses categorised as CRITICAL THINKING expressed the student's perception of Statistics as a guide to abstract thinking and intellectual empowerment. Tilly (Cluster 1, in section 7.3.2.3) expressed her triumph at overcoming her previous barrier to understanding mathematics or statistics. Sandra, in Study One, also indicated this idea of learning Statistics as leading to personal development when she concluded about mastering Statistics:

> It felt very good, it felt a lot like growing up.

My analysis of students' conceptions of Statistics was holistic. In Study One students' conceptions of Statistics emerged from verbal descriptions of their experiences, actions and evaluations. In Study Two, a relational analysis of students' conceptions of Statistics was furnished by Marton's (1986) phenomenographic methodology. Students' responses to the three open-ended survey questions were interpreted as a whole. Hence students' responses to questions asking about their feelings about learning Statistics, their actions and intentions were taken into account to build up a picture of their conceptions — rather than only responses to Question 3, which focused directly on these conceptions.

9.2.1.1 Meaning And Personal Sense

The holistic analysis, referred to above, illuminates in my project an important, and little recognised, aspect of Leont'ev's theory — the difference between meaning and personal sense (Leont'ev, 1978). As explained in section 2.2.2, meanings to Leont'ev are socially endorsed and are independent of their relations to the individual's life. Personal sense, on the other hand, involves the embodiment of these collective meanings into the individual's own system of consciousness in:

> a deeply intimate, psychologically meaningful process (Leont'ev, 1978, p. 93).

For example, Colin, interviewed in Study Two (section 6.7.2) expressed as follows his effort to incorporate mathematical meanings which were acceptable to the scientific community into his personal understanding:

> ... I grapple with it and I come to that sort of arrangement which satisfies the general understanding as well as my own.

Leont'ev emphasised that this difference between meaning and personal sense is not a difference between the logical and the psychological, as meanings only exist in the minds of people. For example, he argued that there is no concept of a "triangle", only people's concepts of a triangle. Rather the difference is between the general or collective meaning and the individual version. To Leont'ev, personal sense is determined by the motive of activity: —

> the question of sense is always a question of motive (Leont'ev, 1978, p. 173).

The following example, comparing two students' survey responses in Study Two, illustrates this incorporation of motive into the categories of conception. That is, the example shows how the categories for the conceptions of Sally and Nellie expressed these two students' personal sense of Statistics. Sally, whose conception was categorised as TOOL, and Nelly, whose conception was classified in the PROCESSES category, both wrote responses to Question 3 which reflected culturally approved "meanings" of Statistics.

Sally wrote:

> *Providing a basis of statistics that can be used in Psych and giving us an understanding of what psychological numbers mean.*

Nelly wrote:

Application in Psychology. Ways in which to provide evidence for experiments.

However as can be seen from their responses, below, to Question 2, the intentions of the two students differed markedly, leading to the different classifications.

Sally’s strategy was:
2a) *Doing practice questions until I understand.*
Her goal was:
b) *an understanding of how to apply it all to real life.*

Nellie, too, emphasised practice, but, evidently, her aim was to use the template provided by class exercises in order to satisfy assessment demands. Her responses were:
2a) *Repetitive exercises*
b) *A pass.*

On a more personal level, Sally wrote in response to Question 1 that the knowledge she was gaining in Statistics was helpful for “archaeology practical methods”, while Nellie’s response indicated only that she hated mathematics and was “never good at it”. This example indicates how Sally and Nellie embodied their different personal senses of Statistics into their responses to Questions 1 and 2, while incorporating similar socially endorsed meanings of Statistics in their responses to Question 3.

The results of Study Two suggest that the collective or social meaning of Statistics to the students was as a body of information produced by experts. It was to be mastered by the students because it was a necessary and important component of the academic course in Psychology. This institutionally constituted meaning is inherent in the fact that Statistics is compulsory in the Psychology course and accounting for 25% of the assessment mark for Psychology II. Teachers of Statistics are charged with the promotion of this collective meaning of Statistics. That students “assimilated” this meaning in Leont’ev’s terms (Leont’ev, 1978, p. 92) is demonstrated by their responses to survey Question 1. As Figure 6.3.1 (in Study Two) shows, the, unspecific, reason: NECESSARY FOR PSYCHOLOGY was cited more often than any other reason in favour of learning Statistics — by the students unwilling to study Statistics (the "NO" students) as well as by those in favour of doing so ("YES" students).

For the majority of the participants of Study Two, the personal sense of Statistics emerging from the phenomenographic analysis, was of Statistics as a body of inert information. The purpose of most students in learning it was to pass, or do well in examinations. That is, learning Statistics was a means to an end. One mature, male student indicated that he was not even attempting to embody the social meaning of Statistics into his personal psyche. In the survey he wrote:

Q1 *No — but it is integral to psychology so I guess I have to!*
Q3 *Not sure — too busy trying to grasp the formulae.*

A similar gap between the meaning of Statistics as a goal of education and the way it was actually assessed was evident in the account of one of the teaching staff, whom I denoted by Cathy. As reported in chapter eight, her view of the purpose of the statistics component of the Psychology II course was as follows:

> First of all, in reading the literature, understanding what other people have done in their experiments and secondly to help them, if they carry out their own research as well, to understand how we have to make sense of numbers and what we do with statistics.
>
> ...
>
> to use it as an aid to systematic thinking and detecting effects amongst all the noise.

This indicates that Cathy's objective in teaching Statistics was for it to be a "sign" (Vygotsky, 1978, p. 55) to students — to enhance their perspectives, as well as a tool for getting results in real life. However, asked how this understanding was measured, she indicated a preoccupation with procedural knowledge. She replied (see p. 244) that the tests showed what students could "do with it". And:

> Once you can force them to write out their answers, you can see if they're understanding it. And if they can apply formulae.

Cathy's comments, above, also suggest her awareness of the imposed nature of the learning task — that students are coerced into acting.

Students appropriate (Rogoff, 1995) in different ways the meaning of Statistics as conveyed to them by their teachers. Norman's expressed goal in learning Statistics accorded with the way Cathy indicated students' knowledge was actually being assessed, rather than the ideal she expressed. He said (in section 5.2.3):

> I have a very pragmatic approach to university, I give them what they want. Arguably if I could guarantee enough knowledge to get full marks in the tutorial test and the stats exam and know that I forgot it all completely afterwards, I'd almost go for that course, because that's what they want.

My data shows that for some students there is a mismatch between personal, subjective meanings, which reflect an individual's life experiences and external meanings, which may be imposed. This fits with Leont'ev's (1978) suggestion that personal meanings do not always fit with socially standardised meanings. Leont'ev (1978, p. 93) proposed that, to the individual, collective meanings are:

> externally 'ready' meanings — meanings, perceptions, views that he obtains from contact with one another form of individual or mass communication.

He expresses a mismatch between personal and collective meanings by referring metaphorically to personal meanings which:

> begin to live as if in someone else's garments (Leont'ev, 1978, p. 93).

This gap between personal sense and externally imposed meaning emerged from the interview data in Study One. For example, Alice indicated how her own meaning making was constrained by the institutional setting. She felt powerless to create personal meanings in Statistics from the formalised knowledge she was appropriating. She said (section 5.2.4):

> I don't translate from maths terminology because one has to learn the terminology to put in for exams, so I may as well learn it right away, instead of translating to English and back. I'm terrified of doing that.
> ...

> If you started to be creative with it you'd run into the most appalling trouble — go off at a tangent. I'd never go outside what's in the book.

Many of the surveyed students appraised Statistics as personally unappealing, for example, boring (see Table 6.3.1 in Study Two). To Leont'ev (1978, p. 95) internal experiences such as interest or boredom are functional to the individual, they:

> signal the personal sense of events taking place in his life.

That is, they are instrumental in incorporating social meanings into personal understanding. Tessa's metaphor for Statistics as a "friend to psychology" (in Cluster 3, section 7.3.2.3) is an example of affect signalling sense in a benign way.

In summary, the analyses in Study One and Study Two show connections among students' affective appraisals and conceptions of Statistics expressed through their actions to learn it. Leont'ev's theory explains the mechanism underlying this relationship as a functional one — affective elements actualise the embodiment of social meaning as personal sense in students' minds and lives (Leont'ev, 1978). My project illustrates and substantiates this mechanism in specific, concrete circumstances.

9.2.2 The Activity Of Learning Statistics

Leont'ev's distinction, discussed above, between meaning as collectively produced, or "co-knowing" (Leont'ev, 1978, p. 60) and individually appropriated (Rogoff, 1995) personal sense, highlights my fundamental thesis drawing on the activity perspective on learning. This thesis is that learning develops in the relationship between the thinking, feeling and acting individual and the sociocultural world surrounding her. The strength of activity theory lies in the explication of this relationship by means of goal directed actions which may be cognitive or overt.

9.2.2.1 Actions And Operations

In analysing the structure of activity, Leont'ev (1981) differentiates between different levels of action (described in section 2.4.4.2). Activity comprises of goal directed and effortful actions, which may, in turn include operations. These are the more mechanical and routine components of actions.

Statistical activity requires problem solving — not the sets of practice examples referred to by the students in this project, but the engagement with and organisation of knowledge. It is by engaging in cognitive and practical activities that students internalise and structure new and functional knowledge. This is the:

> laying down a path in walking

in the idiom of Varela et al (1991). Hettie, in Study One (section 5.2.4) highlights the essence of activity when she describes how she purposefully and energetically appropriates culturally formed, statistical knowledge available to her in the form of lecture notes and examples worked by her tutors.

> But you really need to take every little bit and break it down, every equation and break that down and understand what it is, and actually do it yourself.
>
> .....
>
> The only thing it will hook into is the tutorial exercise you did last week. When you've actually done it. It's not a thing that's not graspable — it's just a thing I had to grapple with and put in some time.

The operational level of action, on the other hand, requires merely a mechanical retrieval of knowledge that is already organised — treading well traced paths of action. In Norman's words:

> Practice and repeat is the key. ... Compare the test question to the tutorial question, if they're the same, apply the same formula.

9.2.2.2 Approaches To Learning Statistics

Leont'ev's (1981) differentiation between levels of activity resonates with ideas of phenomenographic researchers (Marton, 1988; Marton & Säljö, 1984; Marton, Watkins & Tang, 1997) concerning deep and surface approaches to learning. The different forms of action, like different approaches to learning, provide access to distinct kinds of knowledge. Learning Statistics has two separable and identifiable aspects. One aspect, dealing with the algorithmic component, involves the process of recognising, applying and remembering mathematical techniques and skills. This knowledge may be accessible through operations. The other consists of an interpretative component and entails analysing the problem, inferring a suitable technique for solving it and clarifying the result. This requires activity — grappling with the problem; engaging with it. The algorithmic aspect requires the learning of a sequence of steps, for which some rote learning is required as part of the learning technique. For this a surface approach may suffice. Interpretation and generalisation are only possible, however, when each step has been grasped on its own and in relation to the whole. If a blind memorising of disconnected mathematical skills and meaningless algorithms is all that is achieved, there will be no basis on which the learner can build understanding and conceptual knowledge. Wendy (p. 254) echoed this view when she related her perception that "the formulas are gone by Xmas" but what stays are the concepts and that:

> the students can't tap into it until they sit down and have that 'Aha!' experience.

Sandra (in Study One) demonstrated her awareness of the different ways of approaching learning Statistics and reported on how she chose to act:

> It's almost like two separate things in the statistics course we've just done. You could have actually just got the steps and maybe not understood why you were doing it. I wanted to understand what I was doing.

A useful characterisation of approaches to learning in terms of figure-ground relations is provided by Marton (1988). In a surface approach to learning "the sign" is figure and "what is signified" is ground, while in a deep approach the opposite holds true (Marton, 1988, p. 65). In other words, a student oriented to a deep approach focuses on the underlying structure and meaning of the material with the intention of understanding it, while a learner adopting a surface approach, in Marton's terms (Marton, 1988) focuses on the details of content with the intention of memorising and reproducing them. Further, Marton (1988) emphasises that a student's approach to learning is a relation between the individual and the learning event, not an immutable characteristic of the learner.

In order to alternate deep and surface approaches to learning Statistics effectively, or, in Marton's (1988) idiom, to interchange in a germane way the “figure” and “ground” — the selection, use and evaluation of cognitive routines and skills must be appropriately regulated by the learner. Sandra’s analysis, above, shows that this regulation depends on the learner’s interpretation of the setting. In the setting of project management, a learning activity is perceived as training rather than education. The goal of learning is seen as the assimilation of a mental body of content and a set of technical skills and mistakes are viewed as costly (see Gordon, 1992b; Wertsch, Minick & Arns, 1984). Actions in this framework are directed towards a quantitative outcome of learning disregarding the quality of learning. If a student interprets the task of learning Statistics in the project management framework, this could lead to an emphasis on the operational component of the cognitive activity — an approach to learning Statistics which is essentially algorithmic with little importance attached to conceptual understanding. This may also be an excessively “surface” approach to learning as I am interpreting the construct (explained on p. 186). In my view (clarified in Gordon, 1992a) statistics recipes have their part to play in the learning process, but must be followed from the active, accountable and reflective vantage point of the cook, not the kitchen hand.

9.2.3 Students’ Positioning With Respect To The Task

Students’ orientations to learning Statistics involve positioning themselves in the arena of the task. One way of describing the position of an individual is in terms of the cultures of the organisations and social groups of which the individual is a part. Hofstede (1991) describes five dimensions of culture that operate in the formation of organisational systems. They are: masculinity versus femininity, individualism versus collectivism, power distance, avoidance of uncertainty and long term versus short term needs. The first concept refers to the distribution of roles between the sexes. Individualism versus collectivism indicates the degree of integration of individuals into groups. Power distance is seen by Hofstede (1991, p. 28) as the extent to which less powerful members of organisations and groups:

> expect and accept that power is distributed unequally.

Avoidance of uncertainty is expressed in the need for written and unwritten rules. Tolerance of uncertainty differs for different cultural groups. The final dimension concerns the trade-off between the gratification of long term and short term needs.

Each of these ideas is useful to examine how the participants in my studies positioned themselves.

9.2.3.1 Masculinity Versus Femininity

Gender roles are an integral part of a person's socialisation in general and of his or her mathematics education in particular (Forgasz, 1994). In Study Two, gender roles may explain the apparent paradox concerning students' conceptions in the TOOL category. As described in section 6.4.3, a substantial and statistically significant difference was found between the proportions of females and males whose expressed conceptions of Statistics fell into the TOOL category (see Figure 6.4.2). However, while more females were in the "General" TOOL sub-category, than in the "Personal" TOOL sub-category and the CRITICAL THINKING category, the reverse was true for the male students (shown in Table 6.4.2). I have suggested that this reversal of positions reflected the females' greater acceptance of their teachers' views about Statistics, rather than their own higher, personal awareness of its relevance and use.

This conclusion is consistent with the students' reported approaches to learning Statistics as measured on the Approaches to Learning Statistics Questionnaire (ALSQ). There was no statistically significant difference between females' and males' scores on the Deep Scale of the ALSQ. In particular, efforts to make the learning personally meaningful did not appear to be dependent on gender. However, females were shown (in section 6.5.2) to have higher scores on the Surface Scale, on average, than males. This seems to reflect a greater concern, in general, by females with satisfying assessment demands and a more compliant attitude to authority. For example, there was a significant difference ($t=2.8$, $p<0.01$) between female and male average scores on item 27 (below) of the Surface Scale of the ALSQ. Females averaged 3.8 on this item, compared to 3.3 for males.

I am very aware that teachers know a lot more statistics than I do, so I concentrate on what they say, rather than rely on my own judgement.	1 2 3 4 5

These findings suggest that the female participants of Study Two, more than the males, incorporated the authoritative meaning of Statistics into their conceptions of it and adopted a relatively passive approach to learning Statistics, dominated by their perceptions of assessment requirements. These gender differences may mirror prevalent values and expectations in mathematics education in Australian society.

9.2.3.2 Individualism Versus Collectivism

In individualistic cultures the interest of the individual prevails over that of the group. According to Hofstede (1991, p. 63) education in individualistic cultures:

> aims at preparing the individual for a place in a society of other individuals.

This emphasis is on providing the skills necessary for that person's ongoing achievement in life. In a collectivist culture, loyalty to the group is paramount. The individual is protected while he or she learns how to do things in a way that is acceptable to the group. In my project, some of the female participants appeared to need the security afforded by collectivism. For example, Sandra, in Study One (section 5.2.4) expressed the need for the support of her peers although she knew that she had to stand on her own two feet:

> I didn't work a great deal on my own, although I did at the end. I had to go through it on my own — but I felt frightened working on my own.

Alice, too, reported the confidence she gained by working with others, both in her catering work, when "there were two of us doing it" (see section 5.2.2) and in studying Statistics. She said (in section 5.2.4):

> ... I can do all those (statistical) test things with the others around a table, we can get them right.

Paradoxically, universities emphasise individual achievement and action, but also set up strong norms in accordance with which students are expected to act. For example, lecturers and tutors put questions to their classes but usually do not expect individuals to answer them in an idiosyncratic way, nor to raise their own concerns in the lecture theatre or tutorial room.

Educator, Wendy explained her management of her class of students as follows:

> I tend to roam around the classroom. Basically to see what's going on.
> ...
> 'OK, do you understand?'
>
> 'Mmm'.
>
> 'How come you're not writing it down? How come that's wrong on your page?'

This suggests that there is a tension between the requirement for students to behave in ways that conform to the position assigned to them as subordinates, which means following the intellectual paths carved out by their educators, and to exhibit the creativity and ability which is rewarded in the academic environment.

Competition is an important element in determining the relative strengths of individualism and collectivism in the culture. Most students learn mathematics at school in a competitive environment with the emphasis on external assessment. At university students are also faced with an environment that favours competition over cooperation. As Wendy pointed out (section 8.2) students who desire to gain entry to Honours in Psychology are vying with their colleagues for a small number of places. Some students may see such competition, with its accompanying focus on assessments, as diverting them away from orientations that emphasise understanding and personal meaning. One student, (see section 6.4.2: NO MEANING) who reported his aim as getting into Honours, even saw Statistics as being about

> the Uni having something they can use as a means to assess our performance.

9.2.3.3 Power Distance

One important aspect of positioning is that of power differences — how individuals deal with inequality in their societal institutions. Hofstede (1991) argues that power distance is explained from the value systems of the less powerful members. That is, authority and culturally prescribed norms are only effective if accepted by the subordinates in the group. Students' experiences in their families, schools and other institutions lead to patterns of behaviour in higher education. While non typical behaviour arises in every group, the impact of family and societal norms is strong. The relationship between students' compliance and their independence reflects such power distances as well as individual differences.

Gender roles and the degree of individualism and collectivism in a group are both closely tied in with the power structures acting within that group. As mentioned before, the higher scores of the female students, compared to the males, on the Surface Scale of the ALSQ suggest compliance with authority, for these participants of Study Two. Similarly, in Study One, the female students showed a desire to conform to institutional norms as they saw them. Alice interpreted her role as a Statistics student as subordinating her intelligence and understanding to the intellectual authority of the lecturer.

> In the lectures I was sitting watching him go through the overheads of our notes and if he said: 'This is very important.', I would underline it and if he said: 'Don't worry about these pages.', then I wouldn't worry about those pages. I assumed the man knew what he was doing because he wrote the notes!

Hettie (in section 5.2.4) as an ultimate expression of powerlessness, compared herself to:

> the rat I'd been observing in the laboratory earlier on.

On the other hand, Norman, while taking a "pragmatic" view of his role as a student, assumed some power when taking on the role of the teacher (see section 5.2.4).

> I invariably picked up some understanding anyway. Compared to Sandra and Alice. When I worked with the others as a group then I would try to do more of the understanding.

Hence, the different roles adopted by students, pertaining to gender or to interchanging "teacher-student" parts, are instrumental in constituting students' power distances.

9.2.3.4 Avoidance Of Uncertainty

Feelings of uncertainty are experienced by individuals and groups. These feelings, and the ways of coping with them, are embedded in the cultural heritage of societies and are reinforced by institutions. For example, students in higher education often express the need for clear structure and goals to be set by their lecturers (Ramsden, 1992). As academic, Wendy, saw it:

> ... you're getting very much a school mentality: 'I want to be taught'.

Too much uncertainty creates anxiety. Too little, leads to rigidity and boredom. My findings suggest that the participants of Study Two, in general, showed a low tolerance for uncertainty, where Statistics was concerned, preferring the reassurance of explicit rules and guidelines from their teachers. For example, scores on the survey item 19 (below) were almost universally high. For that reason, this item was not included in the final version of the ALSQ. The average score on this item was 4.2, demonstrating the surveyed students' preference for teachers of Statistics who spelled out the content unambiguously.

I learn statistics best from teacher(s) who work from carefully prepared notes and outline the major points clearly for me.	1 2 3 4 5

The "certainty" of mathematics is often what appeals to people. As educator Cathy explained:

> I love teaching statistics. The rest of psychology is so waffly in many ways. I feel statistics is just less so.

On the other hand, the opposite was expressed by a participant of Study Two who wrote:

> *I find that statistics is too rigid.*

To Norman, in Study One, the idea of playing with explanations for the inexplicable was appealing. When asked if he would study mathematics further, he answered (in section 5.2.5):

> I do quite like abstract ideas. Similar sort of learning — the curiosity to know and explain something via numbers and equations. I can see if that was a strong feeling with me I would find it fascinating. Read a paper by someone who tried to mathematise thinking — pages and pages of equations to explain how human beings think. It sank without a trace but I could see an interest on those sort of levels.

As with any personal assessment, there is diversity in individuals' needs for freedom and for bounds.

9.2.3.5 Long Term Versus Short Term Needs

In Leont'ev's theory, motivation is central to activity as the energiser of actions (Leont'ev, 1981). Motivation also provides an analytic perspective on activity. Motivation refers to the needs standing behind students' actions. One way of understanding why students act as they do relates to the tension between gratifying long term needs and short term needs. In section 6.3, I analysed students' reasons for their willingness or reluctance to study Statistics. These reasons can be seen in the light of satisfying long term or more immediate needs. The long term needs reported by the participants related to their future lives: further study, careers or jobs or self empowerment. Short term needs, on the other hand, referred to immediate interest and challenge or enjoyment, or simply fulfilling the immediate requirements for Psychology II.

Study Two showed that few students found Statistics personally challenging and fulfilling and most adopted primarily surface approaches to learning it. Hofstede (1991, p. 153) suggests that extrinsic factors have to be present in order "to prevent *de*motivation". Educator, Wendy referred to this when she said:

> My theory is — people only work with a carrot or a big stick. And I think the tests act as a stick.

In particular, over 90% of the students who fitted the Cluster 4 profile (shown in Figure 7.3.3 and Table 7.3.7) expressed reluctance to learn Statistics. Such students, who lack intrinsic motivation to learn Statistics, are unlikely to work at it at all if not for the "stick" of a substantial assessment weighting in Psychology II. However, experiences of learning Statistics simply to pass impending examinations are unlikely to encourage a relational understanding of it. As Narelle (Cluster 4, section 7.3.2.3) reported:

> I'm trying to get the relevant information from the problem without being distracted by so much to think about, like the whole experiment.

Until university education addresses this issue, many students will not recognise the possibilities for using statistics in different contexts in their lives.

Semenov (1978) proposes that the personal plane dominates students' actions. That is, Semenov proposes that students' reflections on the meaning and success of the ongoing mental activity guide their thoughts and actions. My findings indicate that it is the intrinsic factors that are the "real" motivators, the factors that lead to students' intellectual and personal development. Hettie (in Study One) demonstrated the tension between meeting her need to get good marks in the short term and satisfying her own sense of self fulfilment when she said:

> I wouldn't choose to go on with statistics, because it's not an area where I get very good marks, and in the end that does matter. It's one of those things that when you get a bit of a handle on the fundamentals, then you've got something to build on — so it doesn't intimidate me. In fact I get this strange sort of satisfaction out of doing the tutorial exercises now. It's like a puzzle. While I'm actually doing it, I quite enjoy doing it. It really bolstered my self confidence.

9.2.4 Systemic Relationships

The five dimensions of culture proposed by Hofstede (1991) have provided me with various viewpoints with which to view a complex network. Though analytically separate, each of the dimensions discussed in the sections above, such as power distance and avoidance of uncertainty, is related in a dynamic way with the other planes of culture which I have described. For example, I have given examples suggesting that gender roles are linked to assessments of power distance and to collectivism versus individualism. I have also indicated the diversity of individuals' positions on each of the five dimensions discussed. Hence Hofstede's (1991) set of five complex and inter-related cultural facets provide analytic vantage points on an "activity system" (Engeström, 1993) which:

> integrates the subject, the object, and the instruments (material tools as well as signs and symbols) into a unified whole.

Universities have established themselves as systems of activity (Leont'ev, 1981, Engeström, 1993). That is, they have developed rules and traditions which define competence or expertise and which frame the task of learning Statistics. Success at university depends not only on students' abilities and skills but also on their abilities to engage successfully in the discourse, norms and practices of the particular community of practice (Lave & Wenger, 1991). The community's culture is the basis for judging success.

Individuals orient themselves in accordance with their assumptions of what is valid or strategic for a given situation. For example, in real life, faced with a problem of making a decision on the basis of data, a range of strategies would be employed, including discussing the problem with colleagues and experts. A statistical problem encountered in an examination is not the same as the statistical problem encountered in the vocational arena. The assumed superiority of abstract thinking, such as mathematical thinking, in solving statistical problems at university may be more "a matter of faith and tradition" (Säljö & Wyndhamn**,** 1993, p. 339) than a rational way of valuing human problem solving skills. Measuring such skills in traditional type examinations, particularly multiple-choice examinations, is particularly problematic, as demonstrated by Norman's method of solving examination problems. He said (section 5.2.4):

> To get away with doing it in one and a half minutes a question — anything less than knowing it really, really well — you were in trouble. I had to guess. A lot of multiple-choice questions are really tricks. If two of them are similar, then usually it's one of them.

Students, through their actions and interactions, interpret and reinterpret cultural criteria for success. Sandra overtly distinguished between the institutional designation of success, as enshrined in an examination grade, and her personal sense of achievement when she commented (in section 5.2.5):

> I'm not going to let the exam mark dictate to me my knowledge. Because I knew I had a better grasp at the end of the year and I really felt that if I was doing experimental work I could work out what to do with my stats.

Valsiner (1994) uses the metaphor of "infection" to explain how some individuals succumb to and others resist socially approbated messages.

In summary, culture or "collective programming of the mind" defines norms which distinguish members of one group from another (Hofstede, 1991, p. 5). However, these group norms only partially prescribe the ways in which individuals act and think. Individuals are able to deviate from such "mental programs" and behave in ways that are unexpected, new or creative (Hofstede, 1991, p. 4). Some of this diversity is idiosyncratic. Some of it also depends on how people interpret their positions in their groups or organisations.

9.2.4.1 Analysis Of Context

In this project I have tried to illustrate and extend the activity theory notion of the inseparability of human mental processes, action and the social, cultural and historical contexts surrounding them. However, the definition of context is problematic in any theory. Lave (1993, p. 18) begins her analysis of "context" from the activity theory perspective by acknowledging:

> the historically emerging contradictions that characterise all concrete social institutions and relations.

That is, the relationship between an individual and her world is a dynamic and complex one. It continuously changes as the person engages in practices in her world. Actions are constituted in the relation between the person acting and the competing systems of power, interests and possibilities operating. The academic world, for example, historically positioned its students and staff as set apart from the commercial and immediate interests of society. Traditionally, its activities were focused on abstract and lofty matters, understandable only to an elite few. These traditions affect people's perceptions about universities and the ways in which universities operate today. However, institutions do not exist in a time warp. Currently, in Australia and in other countries, the ivory tower is expected to operate as the glass office block — transparent in its links to the community it serves, accountable to the wider public, serving material gain. The actions of an academic community are linked to the socially structured and historically generated web of activity surrounding it. For example, the progress of technology, particularly electronic systems of communication, means that information once regarded as the preserve of the elite is accessible to a wide spectrum of people.

From this perspective, context:

> may be seen as the historically constituted concrete relations within and between situations (Lave, 1993, p. 18).

This interprets context as the web of relationships of prospects, historically generated meanings and actions forming and reforming the social fabric. The ways people act together in different practices are not isolated activities, each dependent on an immediate situation, but are related and contextualised within working cultural and structural systems of human action, thought and artefact.

9.3 CONCLUSION

Statistical activity at university can be considered in terms of students' purposeful, cognitive and overt actions, such as grappling with ideas or practising examples, and by analysing the ways in which statistical understanding is constituted in interactions and discourse among students and teachers.

The above discussion shows that each individuals thinks, feels and acts according to her own free will, but that this freedom is constituted by and integrated into the social, institutional and cultural environment surrounding her. That is, students' evaluations and the actions they take are tied in with their individual ways of rejecting or accepting social roles, power relationships and other cultural values and expectations. The implications of this view of learning Statistics will be discussed in chapter ten.

CHAPTER TEN

CONCLUSION: INSIGHTS, DISCUSSION AND REVIEW

10.1 INTRODUCTION

My aims in this research have been twofold. My first interest was to raise issues about statistics education at university. As explained in chapter two, there is considerable research on teaching statistics at university. This reflects concerns in the community of statistics educators about setting objectives for statistics education and implementing these objectives in appropriate ways. I have focused on the other side of the coin — students' actions and awareness. This is necessary to see if objectives of statistics education are being met. Secondly, I agree with Miles and Huberman (1984) that a major contribution of any research is the transferable theory that emerges from it. Research cannot be prescriptive but the explanatory power of a theory is useful. In this regard I have tried to apply and extend some of the important and far reaching ideas of Vygotsky and Leont'ev (Vygotsky, 1962; 1978; Leont'ev, 1978, 1981). In this chapter I show how these aims work in tandem. I apply the theory I have developed to understand a system of activity (Leont'ev, 1981; Engeström, 1993) encompassing teaching and learning Statistics within the social, cultural and historical environment of a traditional university and a particular field of practice, psychology. In this way I offer insights on statistics education.

10.1.1 Chapter Preview

In the next section (section 10.2) I summarise and illustrate the theoretical ideas I have developed in this thesis. I first present, in section 10.2.1, a simplified representation of an activity system, which freezes the dynamic and interactive dimensions and transformations of learning Statistics. In section 10.2.2, I view teaching and learning Statistics in the light of my theoretical framework. I discuss tensions inherent in this activity system. Section 10.3 is a discussion of my results and methodology and an exploration of issues arising from them. These suggest directions for further research. I first summarise some important findings that emerged from my analysis in section 10.3.1. In 10.3.2, I review the insights provided by my research methods and explore the limitations of these methods. In 10.3.3, I look at some important and broad issues and implications concerning statistics education in general. How is learning statistics constituted? How can learning statistics contribute to personal development? In section 10.4, I review my research. That is, I analyse it in terms of my dual aims described above. I conclude by raising questions as to what statistical activities are appropriate in our era.

10.2 INSIGHTS INTO AN ACTIVITY SYSTEM

My findings in this investigation have shown that students' orientations to learning Statistics, including their affective appraisals of Statistics, conceptions of it and approaches to learning it, are complex, inter-related and diverse. They reflect what Ainley (1993, p. 396) calls:

> the multidimensional quality of student engagement with learning.

This engagement is the essence of activity as I have developed the construct from Leont'ev's notions (Leont'ev, 1981). How students position themselves to learn Statistics is critical to the ways in which they engage with the learning task and hence affecting the quality of their knowledge.

I have separated, for purposes of analysis, orientations to learning Statistics, activity, outcomes of learning and the surrounding sociocultural parameters, for example, institutional practices. However, as explained in chapter nine, I regard these as complementary aspects of a unified and dynamic "system" (Vygotsky, 1962, p. 8; Leont'ev, 1981, p. 46) — an activity system in Engeström's term (Engeström, 1993).

10.2.1 Model

A simplified schema of this system is shown below in Figure 10.2.1 (p. 281). This summarises the ideas I have raised throughout this project (see, particularly, sections 2.4.4, 2.6, 3.3.2, 3.4.1). The dynamic component of my model is the student's activity — how she engages with the learning task. Activity is shaped by how a student orients herself with respect to the learning task, her goals and needs and the tools and constraints accompanying the task. It also forms these anew as the student's actions, with their ensuing outcomes, unfold. On one plane, a student's actions relate to her purposes and to the resources available, as well as the constraints of the task. In this way, through activity, goals are linked to specific conditions. On another plane, through activity, orientations are connected to outcomes. For example, Tilly (see Cluster 1, section 7.3.2.3) expressed a positive orientation to learning Statistics, saying that she wanted to learn Statistics because she was "interested" in experimental research and would "need the knowledge". Her report indicated engagement — that she persisted with trying to integrate the knowledge and:

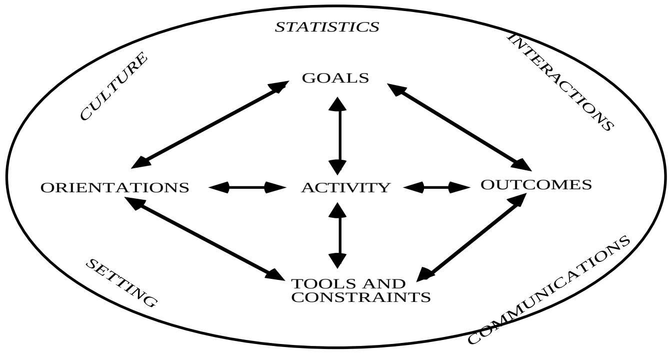
> understand that and therefore know how to apply it.

She achieved success both in qualitative terms — personal triumph at overcoming difficulties — and by the criterion of performance in assessments.

Activity is regulated within social and cultural contexts and also contributes to the transformations of these settings. These links between acting individuals and the world surrounding them are organised through interactions, including verbal communication with other people, such as colleagues and teachers, and through objects, such as books and computers.

Contextual elements are relatively stable aspects of the activity system, compared to individual actions. Institutionalised practices, such as the writing of examinations at universities, seem to reproduce similar actions and outcomes in an enduring and seemingly unchanging tradition. However, cultural practices are also emergent and accommodating of transformations by the actors within them. The environment in which students learn Statistics depends on the long tradition that structures the task. In turn, the students and academics acting in this setting are part of the tradition for those who follow. For example, the comparatively recent use in Statistics of multiple-choice tests, marked by computers, reflects an economic constraint which is fast becoming the norm for higher education in Australia.

FIGURE 10.2.1
SKETCH OF ACTIVITY SYSTEM



Only a frame or snapshot of the activity system can be diagrammatically represented. However, the essence of a working system is the dynamic nature of the mutual transformations within it. My sketch depicts relationships among orientations; activity; goals; tools and constraints; outcomes and contextual aspects. These contextual factors include personal interactions and communications; the institutional setting; the surrounding culture and the task of learning Statistics itself. The relationships among all these elements are mobile and undergo transformations leading to the next phase of the activity system. According to activity theorists, Zinchenko & Gordon, separate actions are distinguished by transformations of the goals, evaluations of the results and transitions to the next action (Zinchenko & Gordon, 1981). Consistent with this dynamic perspective, Cole & Engeström (1993, p. 8) postulate that:

> activity systems are best viewed as complex formations in which equilibrium is an exception and tensions, disturbances and local innovations are the rule and the engine of change.

The activity system encompassing teaching and learning statistics is a complex and fluid formation. It may be transformed by the actions of individual lecturers or by groups of students, for example, acting through a class representative. It is transformed by new resources, such as the availability of technology, or by changes in departmental or institutional practices or by new government policies. Further, it is both dependent on and transforms other activity systems in the social sphere. For example, the curriculum, teaching methods and assessment for

Statistics in second year Psychology are shaped by and also shape the activity system revolving around post graduate research in Psychology at The University of Sydney.

10.2.2 Teaching And Learning Statistics

I turn now to the specifics of one activity system: the system incorporating the teaching and learning of Statistics. I first provide some perspectives on teaching and learning Statistics suggested by the theoretical framework. These suggest tensions in the system.

10.2.2.1 Theoretical Perspectives On Teaching And Learning Statistics

In teaching statistics at university, traditional methods take for granted that students should learn certain topics at a specified level using prescribed techniques without questioning the framework within which this learning takes place. The student's attention, it is assumed, is focused on the content to be learned rather than the learning situation. My project, drawing on activity theory, shows that contrary to these suppositions, students' orientations to learning are mediated by their appraisals of the context and personal sense (Leont'ev, 1978) of the educational practices in which they take part. Further, the outcome of these appraisals may not concur with the objective of university education which is, surely, high quality learning. Statistics is a compulsory component of the Psychology course at the University of Sydney, because it is regarded by those steering the curriculum as being important. Educator, Cathy, saw Statistics as a tool for understanding the research of others and to help them, if they carried out their own research — to "make sense of it". Another staff member, Wendy, from her own vocational experience, proposed that Statistics should lay the framework for understanding things that "come across their desk" (p. 242). Some students' responses in Study One and Study Two, however, indicated a gap between these meanings of Statistics and students' personal sense (Leont'ev, 1978) of it.

Two fundamental principles of activity theory are relevant to address these issues. Firstly, each individual has a history of learning experiences which will influence how that learner acts in a given learning experience. Secondly, the learning task is situated in the university setting, with its own particular traditions and practices. The problems individuals have to solve are structured within the bounds of this setting; individuals become socialised as they act within this arena. The evidence from my investigation suggests that some students behave in ways which we educators do not value but are functions of practices in higher education.

Students have diverse needs and constraints which both form and are transformed by their perceptions of the learning task and their actions in carrying out that task. Some of the responses of the five students in Study One indicated that students may perceive that the main purpose of studying Statistics is to recall information for an examination (Norman), that learning statistics is an uncreative activity (Alice), or irrelevant to the chosen field of study (Hettie), or that only surface approaches to learning are rewarded in the academic environment (Ernest). To many of the participants in Study Two, learning Statistics was evidently about accumulating knowledge for examination purposes — unrelated to applications in psychology and irrelevant to their personal interests and concerns. Nevertheless, for some of the participants (for example, Sandra in Study One and Tilly in Study Two) grappling with the task of learning Statistics led to increased confidence, enhanced insight into scientific thinking and personal empowerment (see sections 5.2.5 and 7.3.2.3).

Statistics, as interpreted by the participants of Study Two, appeared to be overwhelmingly concerned with mastering concepts, techniques and skills — the operations in Leont'ev's (1981) term, in order to do classroom exercises. A lack of awareness of the functionality of these skills and processes made it difficult for the students to experience statistical thinking as personally meaningful. As educator Cathy put it (in section 8.2):

> I think that probably they don't have a clear idea yet. They haven't done any research yet and a lot of them aren't even reading the publications in the literature. They're just reading the general text books or whatever, so I think they're not really yet able to have an overview of what it's all about. How they might ever be able to use it.

Within this context, statistical meaning is reduced to performance on assessment tasks. Moreover, these assessment tasks are imposed on the students with little or no room for negotiation.

Cathy's perception, quoted above, suggests that many students have no experience of appropriating (Rogoff, 1995) statistical knowledge through their own activity — that is, by grappling with new information — to make it meaningful, to relate it to their lives. If, as the activity framework suggests understanding is constituted through personal actions, then the quality of a student's statistical understanding is related to the nature of these actions and the goals directing them. My data suggests that students are taught about statistics which is remote from their own lives and concerns. Hence, I would expect them to interpret appropriate statistical activity as encoding and reproducing this alien expertise. Therefore, it is not surprising that many students took this approach.

The activity framework suggests that the process of learning is important in defining whether that learning will have lasting impact on the students' view of the world. Assessments of the sort written by these students, however, measure a product — what students "know" as indicated by written tests and examinations. This knowledge product, furthermore, may not reflect a student's ability to communicate the knowledge, apply it in different situations or even remember it the following year. Ongoing research by Ellerton & Clements (1997) suggests that students' written mathematical performances may not even match the knowledge product the tests purport to assess. Their study on a well recognised competency test in mathematics revealed that a noteworthy proportion of students (over 25%) wrote correct answers although they lacked an adequate understanding of key concepts and skills while others gave incorrect answers but demonstrated conceptual understanding in interviews.

Activity theory provides us with useful concepts to better understand the dynamics of students' learning and hence with guides for the improvement of teaching. From the perspective of activity theory the role of the teacher is to establish an environment appropriate for educational activities. In this framework, teaching statistics, rather than being the process of transferring a body of statistical knowledge, is the guiding of students to view their learning as relevant and meaningful. For this guidance to be effective, the implicit assumptions underlying the content, presentation and evaluation of the course need to be examined. In particular, the assessment procedure is a powerful signal from the educator to the students. As with any signal, the intention of the sender is not necessarily congruent with the interpretation of the receiver. The intention of the educator may be to ensure that a deep interpretation of the material is achieved by most students, but careful scrutiny of the assessment from the perspective of the student is needed to achieve this difficult aim.

My data has provided many examples showing tensions between the personal meaning of Statistics to students and their actions which are a function of a singular, institutional setting. On the other side of the lecture podium, the effect of the historical and institutional context is equally potent. Those currently organising and reforming, or teaching, the Statistics curriculum have inherited practices from their predecessors. Such practices are not lightly tossed aside, even if they do not fit with personal educational aims of some academics. Statistics, before the technological era, required human processing of quantitative data. An understanding of the concepts and algorithms underlying this processing was valued expertise. My research shows that these historical appraisals are still with us. Cathy recognised that Statistics students were assessed on whether "they can apply formulae", even though she acknowledged that this was no longer relevant. Educators may also act in accordance with an academic system which does not always match their personal planes (Semenov, 1978) — their evaluations of the meaning of teaching and learning statistics.

10.2.2.2 Tensions In The System

The above discussion shows that the activity system of teaching and learning Statistics is neither static nor a "seamless configuration" (Cole & Engeström, 1993, p. 15). The many components and sub-systems operating within teaching and learning Statistics are not necessarily congruent. The interview data from this project, with just two teachers of Statistics and a few students, indicates the heterogeneity of perceptions and conditions surrounding the learning of students. Moreover, there are tensions within the system that are more deep-seated than those presented by individual diversity. Three such tensions which seem to me particularly pertinent are discussed below.

The first tension is between what students perceive as their real needs — their current concerns or their goals for their future lives — and the theoretical knowledge presented to them in the academic context. This tension lies partly in the gap between educational aims and educational practices. This will be further discussed in section 10.3.3. This tension is also inherent in the nature of academic learning as opposed to situated learning (Lave & Wenger, 1991) that is, learning while engaged in statistical practice. For example, research by Martin (1997, p. 339) suggests that in a vocational setting, the factors important for success in learning statistics include:

- relating existing knowledge to the project on hand;
- drawing on knowledge from as many sources as possible via project teams;
- placing theoretical statistical ideas into the realm of "shop-floor" experience;
- relating and distinguishing between evidence (data) and argument.

These capabilities are not usually stressed in undergraduate statistics courses.

The second tension is between the high quality learning that is expected in a university setting and the current conditions surrounding higher education in Australia. These conditions of dwindling resources and increasing demands on both students and staff can lead to expectations of what Grace (1997) terms "the pizza delivery model" of education. That is, conditions can lead to demands for the economical transmission of information, efficiently delivered and in a form that is easy to consume — if not to digest.

The third tension in this activity system is the gap between the complexity and changeable nature of statistics itself in our information rich and technologically advanced era, and the mainly traditional tools and resources available for its teaching. In my experience, it is still common for university statistics courses to rely on the established modes of lecturing and tutoring, centred on the teachers and depending heavily on text books. In Statistics, at the time of writing, only these traditional methods and tools were available. Even where some use is made of computers and other electronic and multimedia resources in teaching statistics, these are often expensive permutations of lectures and tutorials and still centre around the information transmission model.

Finally, we now have to question the very identity of expert and learner in our activity systems. Vygotsky proposed that the young develop through being instructed and assisted by the more experienced members of the community

(Vygotsky, 1962; 1978). However, expertise in our era is as often created by the young and relatively inexperienced as by those more traditionally accepted as the "knowing ones". For example, in Australia, the giant communications corporation, Telstra, recently awarded a one million dollar software contract to an Australian schoolboy with a "backyard" computer company (Evans, 1997). There is a tension between who leads and who follows in the development of abilities and knowledge.

10.3 DISCUSSION

The discussion will focus on three aspects:

- A summary and analysis of the key results;
- perspectives provided by the research tools;
- issues and implications for teaching statistics at university.

10.3.1 Summary And Analysis Of The Key Results

In this project, I have explored a range of orientations to learning Statistics as expressed by the participants of two studies. In Study One, diverse perceptions, evaluations and actions taken were evident in the narratives of the five students. These showed the complex relationships among students' histories, needs, goals and actions, all of which are socioculturally embedded.

My findings in Study Two, with respect to the "YES" students and the "NO" students (summarised in section 6.8) suggest that higher motivational levels are associated with more desirable approaches to learning and conceptions of Statistics and are reflected in better results in tests and examinations. These links should not be interpreted in a positivist way — as higher motivation being the cause of higher marks or more appropriate conceptions and learning strategies. Rather this is evidence for the inseparability of feeling, thinking and acting proposed by Vygotsky (1962, 1978). These associative links were supported by factor analysis and cluster analysis (in section 7.3).

My analysis shows that students' reasons for their willingness or reluctance to learn Statistics (section 6.3.1) were dominated by perceptions of Statistics as uninteresting, unappealing or difficult. This is consistent with research on statistics education (outlined in section 2.2) showing that many students are averse to studying statistics and have a poor understanding of statistical concepts.

Further, although Statistics is a component of wider studies in Psychology, less than a third of the participants of Study Two (those categorised in TOOL or CRITICAL THINKING) expressed an awareness of connections between this statistical knowledge and its applications. Even in this group, most students did not relate those practical applications to their own concerns or futures. The majority of the other students, including almost three quarters of the "NO" Psychology students, reported conceptions of Statistics in terms of learning mechanical procedures or mastering decontextualised concepts and solving classroom problems.

On average, the participants of Study Two reported an overwhelming preference for surface approaches to learning Statistics (see section 6.5.2) — for gaining an inventory of routine skills and operations (Leont'ev, 1981) at the minimum personal cost. Some of these students may have believed that surface approaches to learning Statistics were expedient. Such beliefs may not be without grounds, as a comparison of the Cluster 2 profile with that of Cluster 3 indicates. (See Figures 7.3.2 and 7.3.3 in section 7.3.2.2). Clusters are not indicative of causes. However, they and other data suggest a link between surface approaches to learning and success in assessments for students who have a facility for the procedures. Interview data with Norman (Study One) and Ben (Study Two) attest to the success of such strategies for some. Both these students, who scored very high marks in Statistics, reported their intentions as Ben put it (in section 7.3.2.3):

> to just get through the questions,

whether or not they understood the underlying theory. Even more telling were educator Cathy's statements equating capability in Statistics with an ability to "deal with" formulae (p. 246). However, students who are diverted from a preferred path of deep approaches to learning toward surface approaches, perceived as strategic, are likely to feel disappointed or frustrated, as Ernest in Study One related.

My framework explains that students bring to a learning task perceptions, assumptions and strategies that are grounded in their previous experiences. In particular, mathematics provides the basis for learning statistics. Previous research conducted by colleagues and myself indicated that many students adopt surface approaches to learning mathematics at school and at university and have fragmented conceptions of mathematics (Crawford et al, 1994a). These undoubtedly contribute to the ways students learn statistics. Repetitive and mechanistic ways of learning mathematics could also be related to the aversion to studying Statistics reported by many individuals in my studies. For example, one student in Study Two wrote in his survey (in response to Question 1):

> *No, I hate maths. Can't be bothered getting my head around it again. I can do it quite well, just don't like to think in that way.*

His response of "almost always" (5) to item 7 of the ALSQ shown in Appendix F, indicates that thinking in "that way" was rote learning — going over and over some things in Statistics until he knew them by heart.

The patterns that emerged from my studies are consistent with previous research. They may also match the intuition of some educators. However, caution should be exercised in generalising the results from the particular participants and setting. Research is needed to describe students' orientations to learning statistics in different contexts.

Some wide perspectives on the data are provided by the methods and research tools I used. These are discussed in section 10.3.2, below. I will also consider some general issues suggested by the results, in section 10.3.3.

10.3.2 Perspectives Provided By The Research Strategies

In Study One and Study Two I used an innovative package of research strategies to try and reveal the worlds of the students. By combining qualitative description, phenomenographic analysis and quantitative summaries, I had different lenses with which to view the findings. My aims are described below.

- I proposed to explore patterns in the data as a whole as well as to investigate individual perceptions and experiences.
- I intended to view the data systemically, as is consistent with my theoretical framework building on the work of Vygotsky (1978) and Leont'ev (1981). For this reason, I interviewed teachers as well as students. This also involved paying attention to the dynamics of the relationship between individuals and context. In much research on statistics education the context, taken as the background — unchanging and uniform — is ignored.

- I aimed to use research methods acceptable to the research community whilst acknowledging the role of my own beliefs, interpretations and values. Hence, my findings represent my interpretations of the data, rather than the output of a computer or an "objective reality". I concur with Anderberg (1973, p. 21) that:

  > The analyst's research objectives permeate the entire investigation. They motivate the enterprise and effectively shape the evaluation of observations and explanation of facts as perceived.

No method of analysis has an internal validity of its own. Its worth is justified by its appropriateness for exploring the data and by the value of the results brought out. The different methods and research tools I used led me to discover different aspects of the data and suggested further hypotheses and analyses.

10.3.2.1 My Application Of Phenomenographic Methods

Traditional phenomenography, in Marton's (1986) terms has the aim of constructing categories of conception (explained in section 2.3.2.1). The questions I asked required not only developing the categories themselves but also finding distributions of responses in those categories. I also explored relationships between the conception categories and other aspects of students' orientations. In short, my aims were different to those of traditional phenomenographers.

This extension of phenomenographic methods led to interesting results. My findings showed a relationship between the categories of conception and scores on the scales of the ALSQ, graphically depicted in Figure 7.2.1. This suggested a link between conceptions of Statistics and approaches to learning it — a powerful result not available through direct observation. Moreover, my analysis revealed a seemingly anomalous result — that the NO MEANING group did not have high Surface Scale scores (see section 7.2). Since this result was entirely unexpected, it was unlikely to have been revealed by imposed categories of description or through usual methods of content analysis which are based on the personal knowledge and perspectives of the researcher. Such anomalies challenged my inference of superficial or transparent conclusions, leading me to propose alternative and deeper explanations. Opportunities for finding and validating alternative explanations, and for rejecting superficial conclusions, as is important in good research (Miles and Huberman, 1994) were also provided by the quantitative analyses. This will be discussed below.

10.3.2.2 Interpretation Of Quantitative Results

Important quantitative data have been reported in this project, for example, distributions of students' reported reasons (responses to survey Question 1) and of their conception categories; descriptive statistics, such as means on the scales of the ALSQ and relationships among variables. Analyses of these data are tools for suggestion and discovery. They have added to my understanding of students' orientations to learning Statistics and their ways of experiencing it. That is, I consider that the quantitative data complement the qualitative data in forming the hypotheses and heuristics on which my interpretations and explanations were founded.

In this project, factor analysis and cluster analysis are systematic techniques which have helped me seek regularities and suggested principles and relationships. I chose these methods of analysis because strategies for multi-level investigations seemed to me to be tools which fitted well with the research problem. That is, these techniques allowed for different planes of interpretation rather than producing more absolute or definitive conclusions. For example, the factor analysis suggested that there were different dimensions, such as orientations to learning Statistics and performance on assessment tasks, underlying the variables. I used cluster analysis to complement the factor analysis. Anderberg (1973) suggests levels of sophistication in interpreting clusters. I shall discuss each of his proposed levels with reference to my data dividing students into four clusters (as described in section 7.3.2.2).

At the least sophisticated level, clusters are descriptive summaries of the data, much like a mean or variance. I grouped students into four clusters on the basis of their assessment marks and their scores on the ALSQ. These clusters are well differentiated from each other with respect to the averages on the clustering variables: EXAM1, EXAM2, CLASS1, CLASS2, DEEP, SURFACE. Hence, the four clusters summarise the data on the variables relating to performance and approaches to learning Statistics. These summaries are shown in Table 7.3.6 and Figures 7.3.2 and 7.3.3.

At the next level, the clusters I produced have certain properties. For example, over 90% of the students grouped into Cluster 4 responded in the negative to the first open-ended survey question asking whether they would have studied Statistics had it not been compulsory. In addition, over 80% expressed conceptions that were classified in the first three categories (NO MEANING, PROCESSES and MASTERY). The variables discussed above (CHOICE and CONCEPTION) were not clustering variables, yet students grouped into Cluster 4 had relatively homogeneous values on these variables. Similarly the other clusters shared common characteristics. Hence the clusters suggest a structure for the data.

At the highest level the results of cluster analysis are:

> an aid to reasoning from the data to explanatory hypotheses about the data (Anderberg, 1973, p. 16).

I have argued that the four clusters constitute a proposal about profiles of students' experiences. Each cluster is merely an outline which smooths out the individual diversity within it. However, the different cluster structures offer distinct ways in which groups of students experienced learning Statistics. These hypothetical profiles were illustrated by extracts from interviews with one student from each of the clusters. These vignettes suggest the essence of the hypothesised profile presented by each cluster.

10.3.2.3 Interviews And Conversations

I conducted a number of interviews with participants in this research. In each case I tried to establish a rapport with the person being interviewed, in order to get close to them — to interpret correctly what they were saying to me. Nevertheless not all interviews were on the same level. Some students were eager to express their perceptions. For example, Colin chose to be interviewed and simply arrived in my office (see section 6.7.2). Other participants of Study Two were contacted and gave up their time to help me. Some interviews with the participants of Study One, could be termed personal conversations. Others were constrained by the lack of familiarity of the parties with each other and differences in our relative status. Interviews with academics required some trust on both our parts and were constrained by our relative positions with respect to the research findings. For example, my perspective as an academic in the Mathematics Learning Centre differs from those of academics in other departments.

10.3.2.4 Limitations Of The Research Strategies

A number of questions arise from my methods. How should one interpret interview data, in view of the above suggestion that not all interviews take place on the same footing? What are reliable data? Can existing methods, such as the phenomenographic method, be interpreted in new ways? My phenomenographic analysis of students' conceptions relied on students' written reports, rather than the traditional (Marton, 1986) phenomenographic interview. Is this valid? In short, do we need improved criteria for evaluating how data are collected and analysed?

The research strategies described above were useful in exploring the data. The open-ended questions used in Study Two allowed each student's own awareness of the meaning of learning Statistics to be explored. However, limitations of my methods were also discovered. As for any qualitative interpretation, analysis of data was extremely painstaking and time consuming; I sometimes felt I was "swimming" in the data. Moreover, this method assumes that students understand the questions and are able and willing to express their thoughts in writing. Some students gave too little information for their responses to be classified. For others it was difficult to reach inter-subjective agreement on the classification. Colin's interview report (section 6.7.2.1) suggests that this is a particular problem when students are not confident about their ability to articulate their thoughts. Further, students had a short time to respond to the open-ended questions and only a few lines to write their thoughts. These limitations were unavoidable under the conditions in which the research was carried out and with the resources available to me.

Activities with their accompanying goals unfold continuously over time. My two studies, however, could only capture students' perceptions and actions at particular points in time. For example, as was explained in section 5.2.3, Norman, before commencing his study of Statistics, expressed the goal:

> to learn enough statistics to become an effective psychologist.

At the end of second year Psychology, however, his expressed aim was to get "full marks in the assessments" even if he "forgot it all completely afterwards". In particular the survey conducted in Study Two was a snapshot of an activity system and so cannot capture the movement and transformations that undoubtedly took place. I am therefore unable to assess the directions of these transformations.

This project sets the scene for further investigations. What is needed now is a longitudinal study to investigate how students' conceptions, approaches to learning and outcomes of learning statistics impinge on their continuing education and their practice in fields such as psychology. Research which uses technology, such as video recorders and interactive computer applications to record students' actions at a large number of different times would have been more effective in capturing the dynamic nature of learning than my studies did. Such methods could also compare what students say or write about learning statistics with what they actually do.

My quantification of data allowed overall patterns to be discerned and provides a basis for comparative studies. This can be more difficult if an entirely narrative style is used to describe data. Also, my quantitative analyses provided support for qualitatively logical relationships, such as between conceptions of Statistics and approaches to learning it. However, qualitative data is essential for conveying the richness of human experience. Alice's conception of mathematics as a "whole heap of figures" (in 5.2.2), Ruth's memory of her "frozen fear reaction" to mathematics (in 6.7.1.1) and Hettie's comparison of someone explaining Statistics to having "someone describe a taste" (in section 5.2.4) testify to the power of qualitative description.

If, as Dey (1993) suggests, research is about meaning, then how best to capture and convey meaning is the core dilemma for any researcher. Some researchers choose either qualitative or quantitative methods and defend the chosen path with missionary zeal (see, for example, Menon, 1993). In the end, however, as suggested by Gill (1996) the selection of appropriate research methodology is an act of judgement. My selection of research tools and methods depended on what questions I wanted to answer.

The perspectives provided by the methods and research tools I used suggest some general issues and implications which are discussed in section 10.3.3 below.

10.3.3 Issues And Implications

10.3.3.1 Issues In Statistics Education

The first issue raised by my results is how policy makers can take account of students' personal planes (Leont'ev, 1978; Semenov, 1978). This means acknowledging heterogeneity. The problem of curriculum design is complex, balancing the needs and expectations of society with the various needs and purposes of individuals. In my experience, university statistics courses concentrate mainly on the course content, with little attention to what Leont'ev (1981, p. 60) calls the "energising function" of a student's activity — that student's goals. If teachers of statistics assume that "rational" assessments of their courses will prevail, then they will endeavour to help students appreciate statistics by stressing the usefulness of the subject to their fields. It appears from this study that educators who do that are preaching to the converted. The students who were studying Statistics willingly, did so for just that reason. My findings suggest that those who teach statistics as a compulsory component of an otherwise non-mathematical course need support to explicitly address students' personal evaluations of their learning — in some cases students' dislike of statistics or lack of interest or confidence in learning it.

The second issue concerns the aims of teaching statistics. Most of the students surveyed in Study Two conceived of their learning in terms of standard techniques for analysing data and/or applications of these, with few interpreting it as a guide to thinking and "mastering oneself" (Vygotsky, 1978, p. 55). Although most educators would endorse the utilitarian value of statistics to students, the challenge to educators is to reconcile this instrumental goal in teaching statistics at university with the intellectual empowerment which is surely the aim of any university course. In the words of Coady and Miller (1993, p. 42):

> One central value of higher education is its power to enlarge the understanding and imagination, to produce a perspective on the particular facts and skills which are learned.

Further, the power of a tool lies in its effective use. If students regard their statistical studies at university with abhorrence they are unlikely to see the possibilities for its application in their lives. As one of the "No" Psychology students (in Study Two) wrote in her survey:

I am frustrated that I should need to study this subject in such an in-depth manner when I will have little need for it later on.

I will explore the implications of this issue in sections 10.3.3.2 and 10.3.3.3, below.

The third issue suggested by my investigation pertains to the nature of statistics as taught and learned today. The surveyed students' reported approaches to learning Statistics, described in my summary above (section 10.3.1) raise concerns. It is well known in mathematics education (Gray, 1993), that high level thinking requires some automation of low level processes, the processes which activity theorists (Leont'ev, 1981; Semenov, 1978) call operations. However, as typified by the student who wrote:

maths is a bit like touch typing ...,

a substantial majority of the students surveyed in Study Two approached their learning of Statistics in ways more suited to a training course than to an educational setting. The above quote calls into question whether the type of statistics taught in this course is that which machines do. From the sociohistorical perspective of this research, it is very important to relate the type of knowledge to the emerging ways societies organise work. Older ideas of what humans do in relation to statistics must be rethought. Mathematics as "touch typing" clearly does not fit with human agency in a technological age. Similarly, university courses which adopt an algorithmic approach to teaching statistics may be inappropriate. Such courses may, indeed, be presenting a view of statistics recently described in an electronic statistics study group as a "historical curiosity" (Esslemont, 1997).

Finally, an important issue arising from my data concerns the tension between teachers' responsibilities as managers and educators. The interviews with Wendy and Cathy suggest that in presenting a statistical topic to tertiary students, the statistics educator may think in terms of conveying the content in a way that seems most efficient, that is, by giving clear and detailed notes and examples. Due to the abstract and difficult nature of statistical concepts, the educator has some hard work to do. The educator makes sure that she has researched and understands every aspect of the topic. She analyses the underlying concepts and checks that students can be expected to have the prerequisite knowledge. She ensures that the topic is broken down into logical and sequential portions, that the explanations are clear and succinct, that applications of the concepts are illustrated by means of lucid examples and their relations to other concepts are clarified. She indicates where the topic is leading and works at conveying the information in a way that is interesting, manageable and fits into the fifty minute period.

The student's role in this setting is to write everything down, to nod wisely, and to voice answers to the educator's questions in a way that corresponds to what is in the educator's mind. The student is encouraged to ask appropriate questions, that is, questions indicating how well the student is following the educator's train of thought. Questions indicating the student's awareness of total incomprehension are not appropriate. They waste time — time which could be used to convey more content.

Job satisfaction in this context is high. The educator is satisfied with the careful, explicit and thorough way she has taught the topic, and relieved to have fitted it into the period. The students are happy with their five pages of notes. All these activities of the educator and student are fitting and understandable in the context of project management. If, however, we look at those same activities, regarding the situation as an educational one, it seems evident that the educator has gained far more from her activities than the students from theirs. There are undoubted advantages to using the project management definition of a learning situation — it is an efficient use of time and it is tidy. However, if we do use this labour setting for learning tasks, we should not be appalled at the poor responses of some students in examinations; responses which indicate that some students accept meaninglessness in their learning of statistics.

If we regard statistics as a useful, human endeavour, university educators will need support to ensure that students receive meaningful experiences of doing statistics. Such experiences must go beyond mere "number crunching" so that students cannot imagine that "*computers do all the work*", as one student wrote in her survey (see p. 174). Such support will require more time and better resources than are usually allocated. Furthermore, if learning statistics is to be a dialogue between teacher and learner, and students' actions those of motivated scholars rather than of reluctant trainees, then we, as educators, need to be aware of how students read the signs we unfold.

10.3.3.2 Beyond Competence In Statistics

If our aim is to educate students in statistics, rather than train them to master techniques, then the emphasis of the teaching shifts from content to personal sense (Leont'ev, 1978) from imposed applications to personal connections. For students to find exploring data meaningful, "real" problems must be posed rather than teachers:

> waste hours thinking up the examples,

as Cathy evidently did (p. 243). "Real", not text book, problems are connected with students' concerns. For example Alice proposed (section 5.2.3) that:

> I might be working on, say, motor bike victims as opposed to people who have held their breath under water too long — they've suffered the same damage, but why is this so? That interests me enormously. It would be simple statistics that I'll be doing.

A model for constituting the learning process as a "dynamic system of meaning" (Vygotsky, 1962 p. 8) already exists in higher education. It is the PhD model — how PhD students are nurtured to tackle a thesis.

An important implication of my theoretical perspective is that a student's goals cannot be viewed as isolated and individual but must be understood in the context of institutional or societal forces. Institutions, in turn, are part of communities and cultures. The student is embedded in a hierarchy of systems which are not necessarily congruent. Statistics courses, in common with other undergraduate courses, can suffer from: an overloaded curriculum, imposing too much detail at too advanced a level, failing to connect learning with the world of practice and using forms of teaching and assessment that encourage rote learning (Candy et al, 1994). To promote the ideals of education in the university setting, statistical teaching must overcome such "lamentable lapses" (Candy et al, 1994, p. 84).

Activity, as I have developed the construct, is associated with engaging with a learning task — solving problems. A problem of concern, both to academic institutions and to organisations which employ graduates, is what Billet (1996, p. 263) calls the:

> paucity of transfer from the education setting to other situations.

Billett explains this by the embedding of problem solving in the setting. It explains, too, why so many students find the hardest part of a statistics problem "trying to understand the question". Students may be trying to match the question with one encountered before. For example, Narelle found concepts and skills she had learned in first year in General Statistical Methods "confusing" to her understanding of Statistics. She said (in section 7.3.2.3) that this was:

> because sometimes we have been doing the same sort of problem but doing it round a different way.

The perceived context of an activity determines how it is construed. If students view learning statistics as an enterprise for gaining examination marks then the process of learning is directed towards that end and understanding what they learn is irrelevant. While there is no simple answer to the dilemma, an initial step is for educators to recognise that the learning of statistics as a meaningful activity must be negotiated, not assumed.

10.3.3.3 Educating The Adult Learner Of Statistics

Statistics education could equip students to apply their statistical learning in new and unfamiliar situations. It could enable them to assess critically the ways in which statistics influences how decisions are made in society. It could enable students to develop confidence in using information technology appropriately. It could even imbue some students with the desire to continue learning and applying statistics.

To know what meaning learning statistics has for students, we need to realise what their values are. In addition, we need to clarify our own goals as educators. Do we want to train students or educate them? What do we define as statistical education? According to Davydov & Markova (1983, p. 57), for any educational activity to develop:

> it is necessary to ascertain and create conditions that will enable activity to acquire personal meaning, to become a source of the person's self development.

In particular, with respect to the task of teaching statistics at university, what sort of self-development could students achieve? There are, I believe, three areas in which development could be aimed for: intellectual development, the development of students' conceptions of statistics and approaches to learning it and their personal growth. Intellectual development is characterised by an improved capacity for abstract thinking, better methods of learning, and conscious metacognitive control. Educational activity in this context would be made up not only of those actions aimed at the mastery of knowledge, skills and technical abilities but also of those directed at enhancing mental capacities such as the ability to reflect, to understand the connections between statistical concepts, to see ahead and to generalise. It could also be expected that educational activity would result in students developing their conceptions of what statistics is. My research has shown that many students of Statistics conceived of the subject as a fragmented collection of concepts, formulae and algorithms. We surely aim to teach students to view statistics as integrated and structured knowledge which enhances their understanding of the world. Finally, and perhaps most importantly, an area in which an adult learner can develop by studying a statistics course is that of personal growth. Simons (1987, p. 58) emphasises that up to now attention has been focused on performance, while excluding the:

> more complex changes that occur in students.

My data shows that some students who succeed in overcoming their reluctance to tackle mathematics or statistics courses, who conquer long standing difficulties with mathematics or a severe lack of confidence in their abilities to do mathematics, report feelings of achievement. As Sandra's and Hettie's experiences indicate, students can find learning statistics empowering.

The theoretical perpectives of Vygotsky (1978) and Leont'ev (1978) posit that society and individuals change and evolve together. It is through educated and thinking individuals that societies are enriched. Individuals, in turn, benefit from the progress of their communities. Statistics education has an increasingly important part to play in this dynamic relationship. Technological advances mean that people encounter a rapidly growing mass of information during their lives. There is, therefore, a growing need for statistically educated people who can assess information critically and use it effectively for their own benefit and for that of their communities.

10.4 REVIEW OF MY RESEARCH

In this project I have tried to understand individual perceptions and actions by drawing on a theoretical perspective which is based on the work of Vygotsky (1962, 1978), Leont'ev (1969, 1978, 1981) and other Russian psychologists in the 1930's. The approaches of these Russian scholars, arose, in turn, from a philosophical tradition of dialectic materialism introduced by Hegel, Engels and interpreted by Marx (Van der Veer & Valsiner, 1991). A central assumption of my approach, drawing on activity theory, is that an analysis of particular actions must take into account issues and dimensions neither apparent in the immediate context nor pertaining to the participants of the studies alone. I have tried to explicate facets of the institutional, cultural and social settings integral to the way each individual's learning developed and proceeded. That is, I have viewed students' learning of Statistics as a human practice that develops in a societal and social setting. As explained in chapter three (section 3.4.1), this practice dialectically reflects and transforms the contextual "orbits" in which it is organised.

An emphasis of the dialectic tradition (for example, Marx & Engels, 1970) is the idea that development occurs through the synthesis of tensions and conflicts. The importance of this principle to research is that it orients researchers to look for such tensions. My narrative has emphasised the tension between individual heterogeneity and contextual commonalities. It is also an acknowledgment that sociohistoric and cultural dimensions impact on but are not always congruent with the immediate and personal interactions surrounding an individual.

Within the overall theoretical framework, I have tried to operationalise particular concepts of activity theory. For example, Leont'ev's (1978) differentiation between meaning and personal sense is illustrated in the responses of students and educators (section 9.2.1.1). I have also given concrete examples of Leont'ev's (1981) ideas on activity, actions and operations (section 9.2.2.1). Students' learning activity has been exemplified by the way some students grappled with problems — engaged with them in search of significant, personally meaningful solutions, as Sandra did (Study One). I have illustrated operations by referring to the ways some students use familiar templates to solve externally imposed exercises. This is summed up by Ben's reporting of his actions to process information (Study Two):

> It doesn't so much interest me, but it's easy going.

Leont'ev (1981) rejected behaviouristic notions of immediacy between stimulus and response. He proposed that activity mediates between the organism and the environment (Leont'ev, 1981). To explicate and extend the idea of activity as a mediator I suggest that activity mediates in three different dimensions. These are:

- time;
- the dimension of the individual versus the social;
- the domain of the subjective versus the objective.

Firstly, activity mediates between the past and the future. This happens on the individual plane and on the communal plane. Through her activity an individual's personal history is linked to her future. In the collective sphere, participation in culturally valued practices provides the basis for continuity in a community. Abilities and knowledge historically accumulated, and governed by evolutionary constraints, are carried into the present by the actions and interactions of people. These actions and interpretations become the models and examples for those following.

Secondly, activity mediates between the individual and the society in which she lives. A person is related to her community through her participation in socially embedded practices, which depend for their structure on the tools available and are regulated by interactions using language and other semiotic systems.

Finally, activity mediates between the subjective realm and the objective world. On the one hand, a material object has a subjective aspect — its perceived meaning or meaning in social use. This aspect is what relates the object to a person. Objects are social objects of human perception or intention or are products of human action. Cole & Engeström (1993, p. 14) refer to the subjective aspect of tools, symbols and other cultural artefacts as:

> the cognitive residue of prior actions crystallized in the object.

On the other hand, an idea, thought, or other subjective image can be externalised through action, for example, by speech or writing (Vygotsky, 1962) or has an overt outcome such as a manufactured product. Plans, images and other facets of internal mental organisation are continually transforming and being transformed by external actions, interactions between people and material tools. Both subjective and objective aspects of human life are constituted, not in the head, nor in the external, physical world of concrete objects, but in the performance of social activities (Bakhurst, 1988). In this way they are intertwined and give meaning to each other.

Leont'ev's theory (Leont'ev, 1969, 1978, 1981) provides the conceptual bridge between the inner and outer worlds of humans; between abstract thought and practical actions. Working in a strictly materialist Marxist paradigm, Leont'ev (1978, p. 26) was at pains to explain that thought is:

> living, human activity having the same basic structure as does practical activity.

To me, a more useful way of regarding the link between thinking and acting is in terms of function. That, as Rogoff (1984, p. 7) puts it:

> thought is in the service of action.

In my two studies I have shown that students' thinking about what Statistics is and how it is learned is intricately linked with their actions.

10.5 CONCLUSION

From a theoretical perspective this research shifts the emphasis from the isolated individual and her behaviour to activity — that is, from the seclusion of the individual mind to the acting person inseparable from the cultures and histories surrounding her. From a pragmatic point of view, it shifts the task of the statistics teacher from a preoccupation with how best to present information to focusing on what students are actually doing and on how their goals and evaluations relate to their actions. It points to the need to look for the links between the social environment and the individual, to be aware of and responsive to individual diversity and to regard affective elements as an integral rather than peripheral part of learning.

My investigation raises questions about the central premises behind teaching and learning statistics at university. That is, what statistics should be taught and how is it experienced by students? Mathematics as an exact and elite discipline has led to enormous technological and scientific advances. It is the basis of scientific thinking which underpins statistics and other methods of interpreting our world. The very objectivity and abstraction of mathematics, however, may be its downfall in statistics education in an era when the rapid advance of technology is outstripping progress in solving escalating social and environmental problems. One student expressed her political awareness about the use of statistics as follows:

> When I see a normal distribution I become a little concerned for its use. Who's fitting what into it for what purposes? Who benefits?

Unless statistics can be more successfully embedded in the human problems that concern students — the "personal" plane (Leont'ev, 1978; Semenov, 1978) its relevance will not be perceived and the power of the mathematics on which it is founded for solving these problems will not be recognised.

A great legacy of Vygotsky was to explain that the very essence of human beings, the way we think and act, is constituted in the social and cultural realm surrounding us. In this, Vygotsky challenged the thinking of his era. However, Vygotsky saw instruction as the prime medium for development. We now know that students can monitor their own learning and that of their peers, as Study One confirms. The time has come for us to think about which statistical activities are appropriate and useful for humans in the information era, rather than continuing teaching the sort of "statistics" which could be done by machines, in environments which constitute the teacher as the expert and regulator of knowledge.

My project has shown that students' orientations to learning Statistics are integral to their activities. Further, statistical activity evolves from a dynamic and dialectic process of thinking, acting and interacting in contexts that form and reform statistical awareness. The challenge for statistics educators is to find a way to communicate to enable students to view statistics as meaningful and useful knowledge which promotes their development and helps them tackle the complex issues of modern society. In these tasks there is much work to be done.

APPENDICES

APPENDIX A

GUIDE TO INTERVIEW QUESTIONS FOR STUDY ONE

Can you tell me about the mathematics you did at school?

How did you feel about mathematics then?

Was there anyone who influenced you with respect to your feelings about mathematics while at school? In what way?

What is your concept of mathematics, your personal view?

Have you done any mathematics or statistics since school, apart from your psychology course?

Tell me a bit about what you were doing before coming to university.

Why are you studying psychology?

Where does Statistics fit in?

Before the lectures began this year, how did you feel about taking Statistics?

Think back to the beginning of this year. Describe your initial reactions to Statistics.

What were your goals at that point?

How were you trying to cope with Statistics initially?

Did any changes in your learning pattern occur during the year?

How did you go about learning Statistics?

Were you studying Statistics any differently to studying your other components of Psychology II?

What were you doing in the lectures? Why?

What sort of things were you doing in tutorials? Why?

What else were you doing to tackle your study program in Statistics?

What were you trying to achieve?

What to you would be the ideal statistics course?

If Statistics had not been assessed, but nothing else changed, how would you have approached learning it?

How useful do you think what you have learned in Statistics will be to you?

If Statistics had been optional this year would you have done it?

Some people would say that if you can't cope with statistics you have no business doing psychology. Would you comment on that?

Has anything of value come out of this experience?

Are you going on with statistics in third year?

What are your goals now?

APPENDIX B

* PREPARATION FOR STATISTICS SURVEY

The following survey was part of a research project (Gordon & Nicholas, 1992) into the attitudes of students doing the Preparation for Statistics course, a bridging course for students enroling in second year psychology or postgraduate degrees in public health .

Free Association

1. Write down the first six things that come into your mind when you think about mathematics.
2. Now think about statistics. If anything different comes to mind write it down.
3. Now write down the feelings you had while you were doing that.
4. Who are the people who have most influenced your attitudes to mathematics? No names, just who they are.

Attitudes Questionnaire

1. When did you last study mathematics?
2. What level of mathematics did you study and where, e.g. school, Tafe, college etc.?
3. How did you feel about mathematics when you studied it at school?
4. Can you describe some of the experiences which helped you form these attitudes?
5. How do you feel about studying mathematics/statistics now?
6. What are your expectations of your university statistics course?
7. Imagine yourself in a situation in everyday life where you have to use mathematics; e.g. comparing prices versus quantities, reading surveys and statistics in magazines and newspapers, tipping in a restaurant. How would you react?

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* Material for Study One

APPENDIX C

* MATHEMATICS LEARNING CENTRE ENROLMENT FORM

This information is confidential. It is to help us to evaluate our teaching service and plan for future needs. Thank you for helping us.

FAMILY NAME. . . . . **STUDENT ID NO:**. . . . . . .

GIVEN NAME . . . .

PHONE NUMBER . . . .

ADDRESS . . . .

SUBURB . . . .**POSTCODE**. . . . .

GENDER (please circle) M F

AGE (please circle) 17 18 19 20 21 22-24 25-29 30-34 35-45 45+

COUNTRY OF BIRTH . . . . . **FIRST LANGUAGE**(if other than English) . . . .

PREVIOUS OCCUPATION (if any). . . . .

WHAT COURSE ARE YOU ENROLLED IN (e.g. B.A., B. SC.). . . . .

WHAT MATHS/STATISTICS SUBJECT DO YOU NEED HELP WITH?
(please circle)

MATHS 1 (LIFE SCIENCES) MATHS 1 ECONOMETRICS 1 PHARMACY

STATS FOR: PSYCH II PSYCH 1 PUBLIC HEALTH GENERAL STATISTICAL METHODS

OTHER. . . . .

* Material for Study One

DID YOU ATTEND A BRIDGING COURSE THIS YEAR?

2 UNIT COURSE 3 UNIT COURSE PREPARATION FOR STATISTICS

WHERE DID YOU RECEIVE MOST OF YOUR SECONDARY SCHOOLING? (circle)

SYDNEY ELSEWHERE IN NSW INTERSTATE. . . . . OVERSEAS. . . . .
(which state?) (which country?)

IN WHAT YEAR DID YOU LEAVE SCHOOL?. . . . .

SCHOOL LEVEL REACHED: YEAR 6 7 8 9 10 11 12

MATHEMATICS LEVEL REACHED AT SCHOOL (or equivalent): (please circle)

Primary Year 7-9 Year 10 Year 11 2 Unit Maths in Society 2 Unit 3 Unit 4 Unit
Other. . . . . .

WHAT MATHS (IF ANY) HAVE YOU STUDIED SINCE LEAVING SCHOOL?

. . . .

. . . .

WHY DO YOU FEEL YOU NEED HELP FROM THE CENTRE?

. . . .

. . . .

. . . .

DATE you completed this form.. . . . .

APPENDIX D

STATISTICS COURSE SURVEY IN STUDY ONE

Note: I asked Psychology II students who attended the Mathematics Learning Centre to complete a survey during the second semester. It consisted of completing the statements shown below.

The most difficult thing about learning statistics is ....

An ideal statistics course in my opinion would be ....

The kind of assistance I found most helpful in this course was ....

I describe my temperament as ....

The teaching style I prefer for statistics is ....

My grades on the first semester assessment tests show that ....

My way of learning a mathematical topic is ....

The difference between learning statistics for this course and learning mathematics at school is ....

My main reaction to this psychology statistics course has been ....

APPENDIX E

[*] MATHEMATICS LEARNING CENTRE EVALUATION FORM

PLEASE CIRCLE YOUR ANSWERS

1. For which course(s) at this University are you seeking help from the Centre?

MATHS 1 (LIFE SCIENCES) MATHS 1 ECONOMETRICS 1

PSYCH II PSYCH I GENERAL STATISTICAL METHODS

PHARMACY PUBLIC HEALTH OTHER

2. Age: 17 18 19 20 21-24 25-29 30-3435-45 45+

3. Gender: M F

4. Did you ever sit for the NSW Higher School Certificate?

1. NO **go to 7**
2. YES **go to 5**

5. In which year did you sit for the HSC?

. . . .

6. Which mathematics course did you take in the HSC?

4 UNIT 3 UNIT 2 UNIT MATHS IN SOCIETY OTHER . . . .

NONE—Highest level of maths studied ____________________________________

7. Is English your first language?

YES NO

8. On average, each week this semester I have used the Centre:

1. LESS THAN 1 HOUR
2. 1-3 HOURS
3. 3-5 HOURS
4. MORE THAN 5 HOURS

9. Evaluation of the supplementary tutorials.

I attended the supplementary tutorials at the Mathematics Learning Centre.

Yes No

(If you answered “No” please go on to question 10)

[#] **The best things about these supplementary tutorials were:-**

[#]**The worst things about these supplementary tutorials were:-**

[#]**The supplementary tutorials could be improved by:-**

---

[*] Material for Study One

[#] Space provided for answers

10. Evaluation of Individual Assistance at the Mathematics Learning Centre

Did you attend the Mathematics Learning Centre for individual assistance?

Yes No

(If you answered "No" please go on to question 11.)

#**The best things about the individual assistance at the MLC were:-**

#**The worst things about the individual assistance at the MLC were:-**

#**The individual assistance at the MLC could be improved by:-**

11. Overall evaluation of the service at the Mathematics Learning Centre

As a result of attending the MLC my confidence in learning maths has increased

not at all, a little, a lot.

(Please circle appropriate choice).

I would rate the overall service of the MLC as:-

(Please circle your rating)

7	6	5	4	3	2	1
Excellent		Fair			Poor	

#**12. Are there any comments you would like to make about the Mathematics Learning Centre?**

Date Your name (this is optional)..

THANK YOU FOR COMPLETING THIS SURVEY

APPENDIX F

SURVEY FOR STUDY TWO

*Learning Statistics

Dear student,
It would be greatly appreciated if you would complete this survey on your attitudes to learning statistics and your approach to learning it. The study forms part of my PhD research for the Faculty of Education. My supervisor is Dr K. Crawford, and I work for the Mathematics Learning Centre of Sydney University.

This survey is about your perceptions of statistics and way you learn it. The results will be used both for research purposes and for improving the teaching of statistics. My view is that there are many ways in which statistics can be learned, and that it is important for educators to understand students' attitudes, goals and expectations.

Since I need to understand how different learning styles correlate with examination performance, I ask for your student ID number in order to complete the statistical analysis. All information about participants will be kept strictly confidential. Publications of results will not identify individuals in any way and at no time will any information about you personally be passed on to others.

At the end of the survey you are invited to assist further with the research, with the assurance that you are free to withdraw from the study at any time.

Some of the questions in the survey are open ended, and ask for your ideas. I am interested in what **YOU** think; there are no "right" answers. I hope you will take this opportunity to make your views known.

With Thanks

Sue Gordon (Mathematics Learning Centre)

Note: This study has been approved by the University of Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research you may contact the Ethics Committee (Phone: 3514811).

Participation in this study is entirely voluntary. I would be most grateful if you would complete the questionnaire as fully as possible.

You are welcome to contact me with any questions at the Mathematics Learning Centre, phone: 351 4061

Please detach this page, it is for your record.

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* Font size and spacing has been reduced from the original survey, in some parts, to accommodate the wider margins in this thesis.

Learning Statistics

Please place a **circle** around your answer where it is appropriate:

1) ID Number: | | | | | | | |

2) Sex: Female Male

3) Age: ....years

4) For what degree are you currently enrolled? (e.g. B.A.) ....

5) How fluent do you consider yourself in English?
not fluent fairly fluent very fluent

6) What is the highest level of Psychology you intend (or hope) to complete?
2nd year 3rd year Honours Masters Other: ....

7) What grade in **Psychology II** do you think you will get at the end of this year?

Fail Pass Credit Distinction High Distinction Other:...

8) What grade in **statistics** do you think you will get at the end of this year?
Fail Pass Credit Distinction High Distinction Other:...

9) **Highest** level of **mathematics** completed.
Please circle **one** of the following:
Year 9 or less
Year 10
Year 11
Year 12: 2 Unit 3 Unit 4Unit Maths in Society Other ...
University course (please specify, e.g. Math I).......................
Other (please specify)..................................

10) Have you studied statistics before (**excluding** school and first year Psychology)?
No Yes: General Statistical Methods Yes: Other.................

Please turn over.

Now I would like **YOUR** ideas on the following questions.

----

1) Would you study statistics if it were not a requirement of your psychology course? Please give reasons for your answer.

2) Think about the statistics you've done so far this year.

a) How do you go about learning it?

b) What are you trying to achieve?

3) What in your opinion is this statistics course about?
Please explain as fully as possible

Learning Statistics Questionnaire

Below are a number of questions about your **ways of studying statistics this year**.

For each item there is a row of numbers (1 - 5) corresponding to a five point scale. A response for an item is shown by circling one of the five numbers. The numbers stand for the following responses:

1 . . .	this item is **only rarely** true of me when I study statistics
2 . . .	this item is **sometimes** true of me when I study statistics
3 . . .	this item is true of me **about half the time** when I study statistics
4 . . .	this item is **frequently** true of me when I study statistics
5	this item is **almost always** true of me when I study statistics

Please answer each item. Do not spend a long time on each item; your first reaction is probably the best one. Do not worry about projecting a good image. Your answers are **CONFIDENTIAL**, and will not be divulged to anyone teaching this course.
Thank you for your co-operation.

		only rarely				almost always
1	I concentrate on studying statistics largely with a view to the job situation in the future rather than because of how much it interests me.	1	2	3	4	5
*2	I find that studying statistics gives me a feeling of deep personal satisfaction.	1	2	3	4	5
3	I think browsing around is waste of time, so I only study seriously the statistics that's given out in class or in the course outline.	1	2	3	4	5
[*]4	While I am studying statistics I think of real life situations in which the material that I am learning would be useful.	1	2	3	4	5
*5	I am worried about how my performance in statistics will affect my overall assessment.	1	2	3	4	5
6	While I realise that ideas in statistics are forever changing and knowledge is increasing, I need to discover what is meaningful for me.	1	2	3	4	5
*7	I learn some things in statistics by rote, going over and over them until I know them by heart.	1	2	3	4	5
*8	In reading new material in statistics I find that I'm continually reminded of material I already know, and see the latter in new light.	1	2	3	4	5
9	Whether I like it or not, I can see that doing well in statistics is a way for me to get a good result in second year Psychology.	1	2	3	4	5
*10	I feel that statistics becomes interesting once I become involved in studying it.	1	2	3	4	5
11	In studying statistics I am focusing more on the examples than the theoretical material.	1	2	3	4	5

Please turn over

[*] Included in the Approaches to Learning Statistics Questionnaire

		only rarely				almost always
12	Before I am satisfied, I find that I have to do enough work on statistics until I personally understand the material.	1	2	3	4	5
*13	I worry that even if I work hard in statistics the assessment might not reflect this.	1	2	3	4	5
*14	I find that studying statistics is as interesting as a good novel or movie.	1	2	3	4	5
15	I restrict my study of statistics to what is specifically set, as I think it is unnecessary to do anything extra.	1	2	3	4	5
*16	I try to relate what I have learned in statistics to material in other subjects.	1	2	3	4	5
17	I think it's only worth studying the statistics that I know will be examined.	1	2	3	4	5
*18	I become increasingly absorbed in statistics the more I do.	1	2	3	4	5
19	I learn statistics best from teacher(s) who work from carefully prepared notes and outline the major points clearly for me.	1	2	3	4	5
*20	I find most aspects of statistics interesting and spend extra time trying to obtain more information about them.	1	2	3	4	5
*21	I almost resent having to study statistics but feel that the end result will make it all worthwhile.	1	2	3	4	5
*22	I spend a lot of my free time finding out more about interesting aspects of statistics.	1	2	3	4	5
*23	I find it best to accept the mathematical statements and ideas of my teacher(s) and question them only under special circumstances.	1	2	3	4	5
*24	I believe strongly that my aim in studying statistics is to understand it for my own satisfaction.	1	2	3	4	5
25	I am prepared to work hard in statistics because I feel it will contribute to my employment prospects.	1	2	3	4	5
*26	Studying statistics challenges my views on how the world works.	1	2	3	4	5
*27	I am very aware that teachers know a lot more statistics than I do, so I concentrate on what they say, rather than rely on my own judgement.	1	2	3	4	5
*28	I try to relate new statistics material, as I am reading it, to what I already know.	1	2	3	4	5

Date:...............

Thank you for completing the survey.
Please read the next page

---

* Included in the Approaches to Learning Statistics Questionnaire

Invitation to assist further in the study

Dear Student,

Thank you for completing the survey. It would help me considerably if you would consent to be interviewed (by phone if you prefer) about the topics in the survey. If you are willing to be interviewed please complete the section below.

Your identity and all information recorded will be kept strictly confidential.

Completing this section does not commit you to anything and that you are free to withdraw at any time and without giving reason.

I look forward to talking to you.

Yours
Sue Gordon

I am willing to be interviewed.

First or Given Name (eg Sue, Bill, Kate etc):............. Phone number:........

Signature: ....

If you wish to do so, you may indicate below the times at which it is convenient for you to be phoned, eg office hours, or between 6pm and 7pm, etc.

Best time to phone:.......................................

Signature:................................

APPENDIX G

INTERVIEW CONSENT FORM

THE UNIVERSITY OF SYDNEY

MATHEMATICS LEARNING CENTRE
University of Sydney NSW 2006

CONSENT FORM

Study on Attitudes To And Learning Of Statistics

I ____

NAME STUDENT ID

agree to participate in the research project *Attitudes To And Learning Of Statistics* being conducted by Sue Gordon, Lecturer, Mathematics Learning Centre, University of Sydney, contact telephone number 351 4061.

I understand that the purpose of this study is to investigate and describe university students' attitudes to learning statistics, how it is learned and how this relates to assessable performance. I am aware that the project is being undertaken as part of the PhD thesis of Sue Gordon and that I am at liberty to contact Sue Gordon or her supervisor, Dr Kathryn Crawford (contact number: 351 2618), if I have any concerns about the research.

I understand that the interviews are audio-taped and that the research study is strictly confidential. I agree that data gathered from this project may be published in a form that does not identify me in any way.

I am aware that during the interviews I will be given the opportunity to ask any questions and discuss any difficulties relating to the statistics course material.

I freely choose to participate in the study and realise that I can withdraw at any time and without giving reason.

Signature______________________ Date___________________

Note: This study has been approved by the University of Sydney Human Research Ethics Committee.
If you have any complaints or reservations about any aspect of your participation in this research you may contact the Ethics Committee through the Secretary of the Human Ethics Committee, University of Sydney. (Phone: 351 4811).
You will be given a copy of this form for your record.

APPENDIX H

GUIDE TO INTERVIEW QUESTIONS FOR STUDENTS IN STUDY TWO

Tell me a bit about yourself and what your plans are.
How does Statistics fit into your overall scheme of things?

How are you going about learning Statistics?
What are you focussing on. What are you trying to do actually?
What are you doing in the lectures?
What are you doing in the tutorials?
What else are you doing?

What are you trying to achieve?

Is there anything you've done that you felt "Yes, I've understood this"?
How do you know when you have understood something?
Can you explain what you mean by understand?

If I could guarentee that you'd get full marks in the exam but you'd forget it all afterwards, would you be happy with that?

What do you hope to get out of this Statistics course?

If you had more time would you do things differently?

Did you do any maths in school?
How did you feel about maths at school?
Do you feel the same way about Statistics or do you relate to it differently?

Has your work involved any mathematics or statistics?

So what do think the Statistics that you're learning now is about?

Is there anything you'd like to ask me or tell me?

APPENDIX I

GUIDE TO INTERVIEW QUESTIONS FOR TEACHERS IN STUDY TWO

How did you get involved with teaching Statistics?
How long have you been teaching it?

What do you see as the purpose of teaching Statistics?

What do you hope students will gain from the second year Statistics component of Psychology?

How do you try and get across these aims in your teaching? What do you do?

How do you know if they have understood it?
Can you give me some concrete examples? I'm trying to tell how you decide whether a student understands or not.

Do you see differences in the groups you teach?

Are there any constraints on you? In other words is everything ideal or are things done because of various constraints?

How much control do you have over the way the course is presented?

How do the assessments affect the learning?
What about the multiple-choice examinations?

What do you see as the different goals of the students you teach?.

I'm interested in how this relates to what students think the Statistics course is about?

Do you see students applying the Statistics they are learning?

How do you feel about teaching Statistics?

APPENDIX J

DESCRIPTION OF STUDENTS' REASONS — EXTENSION OF SECTION 6.3.2

In this appendix, I describe the categories listed in Table 6.3.1 (pp. 165-166, in section 6.3.1). This is followed by a table of illustrative examples of each category within the three main classifications: Personal Evaluation; Practical Assessment and Beliefs.

Description of "Personal Evaluation" Categories

Within the PERSONAL EVALUATION (subjective appeal) classification, students' responses were found to separate into favourable or unfavourable feelings towards Statistics in the categories below.

INTEREST	Responses expressing the idea of mathematics or Statistics as interesting or boring.
AFFECT	Affective responses, such as likes or dislikes.
PERSONAL RELEVANCE	Negative responses only. These indicated that Statistics had no personal meaning or relevance to the student.

The following categories of PERSONAL EVALUATION concern the student's image of the self as learner of Statistics:

CONFIDENCE	Reasons expressed in terms of the lack of confidence the student felt about learning Statistics. No positive responses.
MATHEMATICAL ORIENTATION	Reasons were given in terms of whether the student considered herself a "mathematical person" or not.
SUFFICIENT KNOWLEDGE	Some students considered that they had studied enough statistics or mathematics for their future use. These responses were scored as being unfavourable to the study of Statistics.

LACK OF BACKGROUND	Negative reasons relating to the student's background knowledge of mathematics.
NO ESSAYS IN STATISTICS	One student specifically welcomed the lack of essays in Statistics. On the other hand, two mentioned that they preferred subjects which involved essay writing.
MISCELLANEOUS	Miscellaneous, single, personal appraisals which did not fit into any of the above categories.

Description of "Practical Assessment" Categories

Three different aspects emerged in the PRACTICAL ASSESSMENT classification for this group of students. The most frequently cited factors (see Table 6.3.1) concerned the (unspecified) necessity of Statistics for psychology or its (specified) usefulness in other areas. A second area was associated with organisational factors, such as time management or the perceived workload. A third aspect was associated with a shorter term, instrumental goal — the effect of Statistics on marks.

The following categories of PRACTICAL ASSESSMENT were recorded in the general area of perceived relevance of Statistics.

NECESSARY FOR PSYCHOLOGY	Responses indicating Statistics as integral to psychology as a discipline (scored positive) or irrelevant to it (scored negative). These responses were categorised separately to those referring to specific reasons why Statistics was necessary for psychology — such as for careers in psychology.
GENERAL USEFULNESS	Reasons associated with evaluations indicating perceptions of the subject as practical, generally useful in society (or the converse).
RELEVANCE TO CAREER	Reasons in which careers or jobs were specifically mentioned. Interestingly, these responses were almost equally split into positive and negative appraisals.

OTHER/FURTHER STUDY	Responses indicating the importance of statistical knowledge to studying other subjects, or for higher degrees;
NEEDED FOR RESEARCH	Reasons were given in terms of reading research papers or analysing the results of research.

The next two categories of PRACTICAL ASSESSMENT fall into the general area of organisational reasons. There were only a few responses in these categories all of which were negative.

TIME REQUIRED FOR STUDY	Students responses indicated that they would not study Statistics, given the choice, because of the time needed for it.
WORKLOAD	Responses indicating perceptions of a high workload associated with the study of Statistics.

One category of PRACTICAL ASSESSMENT was found to be associated with instrumental reasons:

EFFECT ON GRADES	three negative responses suggested that the study of Statistics was detrimental to the student's assessment results.

Description of "Belief" Categories

In the classification BELIEFS ABOUT STATISTICS, the major category pertained to students' perceptions of how difficult they thought the subject was. Two other categories (with low frequencies) were identified, relating to students' beliefs about statistical knowledge.

DIFFICULTY	Responses about Statistics as hard or easy.
PSYCHOLOGY AS SCIENCE	beliefs pertaining to students' views on using statistics as a basis for psychology to be regarded as a science.
OTHER BELIEFS	various beliefs about the nature of statistical knowledge.

Examples of Students' Responses

Examples of the students' responses are presented in Table J, below. These are broken down into the separate categories described above within the main classifications of Personal Evaluation, Practical Assessment and Beliefs. I have also indicated the number and percentage of favourable and unfavourable responses in each category as shown in Tables 6.3.1 and 6.3.2.

TABLE J
STUDENTS' RESPONSES TO FIRST OPEN-ENDED SURVEY QUESTION

PERSONAL EVALUATION

Category	Examples: Favourable Responses	Examples: Unfavourable Responses
INTEREST	5 responses (2%)	80 responses (29%)
Key Words	interesting	boring, dry, tedious, does not interest me
Excerpts	206: *It's interesting*	106: *cause I generally find it dull, boring and tedious*
AFFECT	13 responses (5%)	37 responses (13%)
Key Words	enjoy mathematics, like numbers, enjoy statistics	hate/dislike mathematics, don't enjoy statistics
Excerpts	245: *I sort of dig numbers*	234: *I dislike maths intensely*
PERSONAL RELEVANCE	0 responses	21 responses (8%)
Key Words	—	pointless, irrelevant, no use to me
Excerpts	—	162: *No, it is irrelevant to my life*
CONFIDENCE	0 responses	20 responses (7%)
Key Words	—	no good at mathematics, anxious, no mathematics ability

Excerpts	—	143: *Maths of any sort immediately makes me cringe*
MATHEMATICAL ORIENTATION	2 responses (0.7%)	13 responses (5%)
Key Words	mathematically minded, mathematically oriented	not a mathematical person, mathematics does not suit me
Excerpts	294: *I am more maths oriented than in other areas ...*	147: *I'm a mathematical vegetable*
SUFFICIENT KNOWLEDGE	0 responses	12 responses (4%)
Key Words	—	done enough statistics/mathematics
Excerpts	—	214: *I've already completed a course + know what it's about*
MISCELLANEOUS	2 responses (0.7%)	3 responses (1%)
Key Words	—	—
Excerpts	288: *I might do because it is different from all the other Arts subjects I do*	304: *Too lazy to practice*
LACK BACKGROUND	0 responses	2 responses (0.7%)
Key Words	—	references to experiences in learning mathematics
Excerpts		58: *I wouldn't study stats because I don't have enough background*
NO ESSAYS	1 response (0.4%)	2 responses (0.7%)
Key Words	no essays	rather write, prefer essays
Excerpts	120: ... — *no essays!*	15: *I much prefer essays (writings)*

PRACTICAL ASSESSMENT

Category	Examples: Favourable Responses	Examples: Unfavourable Responses
NECESSARY FOR PSYCHOLOGY	46 responses (16%)	8 responses (3%)
Key Words	necessary to/ integral to psychology	not related to psychology
Excerpts	228: *It is necessary in the study of psychology*	57: *I am not sure what relationship there is between statistics and psychology*
GENERAL USEFULNESS	19 responses (7%)	1 response (0.4%)
Key Words	useful in many fields, a tool, interpreting issues, practical	not a practical subject
Excerpts	18: *statistics are used throughout our society i.e. newspaper reports & it is important to have an understanding of the way in which information is gathered, processed & manipulated*	115: *No, it is not a practical subject*
OTHER/FURTHER STUDY	14 responses (5%)	4 responses (1%)
Key Words	helpful in studying other subjects, such as, politics, government, archaeology, biology or for future study	not needed for studying other fields
Excerpts	117: *Yes, to assist my studies in politics*	176: *I don't need it for any of my other courses*

RELEVANCE TO CAREER	6 responses (2%)	7 responses (3%)
Key Words	useful for career, useful in job market	no use to a counsellor, irrelevant to my career (as a psychologist)
Excerpts	41: *... if I choose a career in psych it will undoubtedly be extremely helpful and valuable*	282: *Also, irrelevant for my future career*
NEEDED FOR RESEARCH	12 responses (4%)	0 responses
Key Words	vital/necessary/significant for research	—
Excerpts	144: *Yes, necessary for all research*	—
TIME REQUIRED	0 responses	4 responses (1%)
Key Words	—	takes a lot of time
Excerpts	—	28: *... it takes a great deal of time to understand a little*
WORKLOAD	0 responses	3 responses (1%)
Key Words	—	too much work, a lot of work
Excerpts	—	164: *Statistics also involves a lot of work for me*
EFFECT ON GRADES	0 responses	3 responses (1%)
Key Words	—	will fail, pulls marks down
Excerpts	—	58: *it pulls my average marks down*

BELIEFS

Category	Examples: Favourable Responses	Examples: Unfavourable Responses
DIFFICULTY	2 responses (0.7%)	40 responses (14%)
Key Words	easy, not too hard	hard, difficult
Excerpts	2: *It's not too hard*	209: *it is difficult to master*
PSYCHOLOGY AS SCIENCE	1 response (0.4%)	3 responses (1%)
Key Words	proof	attempt to convert into a science
Excerpts	205: *it is incredibly important in the amassing of proof for any psychologist — to act w/out it to be working in an unscientific manner*	194: *attempting to convert an esoteric concept like human behaviour into a 'hard' empirical science is a non-sequitur*
OTHER BELIEFS	2 responses (0.7%)	4 responses (1%)
Key Words	encourages criticism, questioning	too generalised, too rigid, have to apply it, have to use it constantly
Excerpts	2: *encourages criticism of claims put forward*	119: *I find that statistics is too rigid*

APPENDIX K

TREATMENT OF VARIABLES IN STUDY TWO

Many statistical analyses, such as linear regression or analysis of variance, are based on the assumption that variables are of a single type, are continuous and are measured, at least approximately, on an interval scale. The variables I investigate in Study Two are discrete and measured on a variety of scales — dichotomous, categorical, ordinal and interval. This is common in educational research. However, frequently a mismatch between statistical methodology and type of data is ignored or inappropriate techniques used (Carroll, 1961; Jöresborg, 1994). Three distinct problems are encountered. Firstly, there are problems in comparing variables of different types (for example correlations between categorical and interval scores). Secondly, the use of techniques using interval scores (such as those based on the product moment correlation) implies both an ordering of scores and a uniform distance between scores. Finally, the use of discrete data in analyses assuming continuous variables may lead to difficulties in interpretation. Cattell (1978) states that the theory underlying factor analysis implies that scales have a true zero, though he admits that in psychological studies this is “utopian”. Jöresborg (1994, p. 383) makes the point that ordinal variables:

> do not have origins or units of measurement. Means, variances and covariances have no meaning.

Some guide lines for a comprehensive approach are suggested by Anderberg (1973) and Kerlinger (1973). Their approaches take into account the nature of data actually encountered in educational studies and focus on the use of statistical techniques to understand and explore the nature of underlying constructs and highlight structure in the data. I will outline their approach as applied to the variables I investigate in Study Two.

One strategy for the analysis of mixed variable types is to homogenise the data set by converting all variables to one type (Anderberg, 1973). For statistical procedures requiring interval scales, Anderberg (1973, p. 63) presents mathematical and empirical evidence that:

> once an ordering is achieved simple ranks are likely to be as good as most other scores.

Some statistical techniques are remarkable robust to the use of ranks as interval scores. In particular, the product moment correlation coefficient depends little on whether "true" scores or ranks are used (with exceptions leading to negative biases; for example, under-estimations occur if the underlying distribution is logarithmic or exponential). In view of the evidence Anderberg (1973, p.63) suggests that to assign interval scores to nominal or categorical classes:

> the analyst's effort should be concentrated most heavily on ordering the classes rather than making delicate adjustments to the spacing between classes

and that the analyst's "informed judgement" may play a large role. An empirical approach presented by Labovitz (1970) includes ways of checking whether the correlations observed by using ranks seriously underestimate the correlations using "true" scores, as would be the case if the "true" scores are logarithmic or exponential.

In keeping with this approach I have concentrated on ordering the variables in meaningful ways and treating class differences with care. Hence the emphasis of my interpretation is on direction and pattern rather than on the absolute values of coefficients. Most of the variables I investigate are already ordered monotonically. The students' ages in years and their (unscaled) marks on tests and examinations that I use in analyses can be regarded as being measured on an interval or ratio scale, with true zero and uniform distances between marks. Scores on the Deep and Surface scales of the Approaches to Learning Statistics Questionnaire are ordered but the spacing between scores cannot be considered uniform. Here the direction, rather than the magnitude of differences is meaningful. Where the variables I have measured are categorical, the ordering is by means of a hierarchy of classes, showing that each class has a higher level of the given quality than previous classes of that variable (for example, FLUENCY in English, or PRIOR MATHS, that is, mathematics studied previously). The variable CONCEPT (conceptions of Statistics) will be considered to have ordered classes determined by levels of awareness. That is, the CONCEPT categories: PROCESSES, MASTERY, TOOL and CRITICAL THINKING are logically hierarchical and empirically inclusive, as explained in section 6.4.4. The first category, NO MEANING, cannot be considered part of this inclusive hierarchy, either logically or empirically, and students falling into this category are excluded from analyses requiring ordering. Qualitative variables defined as dichotomies, such as gender, are a special case. They are independent of scale (invariant under linear transformations) and can therefore always be included directly in analyses based on interval scales (Kerlinger, 1973; Anderberg, 1973).

In my statistical analyses, the variables are ordered and the classes are treated as though they were equally spaced along the interval scale. Where variables are categorical all data points (individual scores) within the same category have the same value. For example, the variable GENDER has two values: MALE (1), FEMALE (2). In cases where the procedures I use are sensitive to the relative sizes of the different scores (such as in the cluster analysis of section 7.3.2) I have reduced scores to standard form (with zero mean and unit variance). This is done for the sake of comparison with similar variables not to imbue scales with any intrinsic origin. I do not agree with Jöresborg (1994, p. 383) that for ordinal variables, descriptive statistics such as means and variances "have no meaning". Rather, I argue that their meaning is dependent on the context of their interpretation. For example, in educational research, examination marks are usually treated as being uniformly spaced with "true" means, variances and zero. However, the common academic practice of scaling or moderating marks to fit a normal distribution renders this treatment problematic. Further, although quantitavely the difference between examination marks of 10% and 30% is the same as the difference between marks of 35% and 55%, that is, 20%, these differences are not qualitatively identical — in the second case the difference is likely to be between passing and failing.

Finally, I consider the decisive arbitrator of any technique to be its ability to produce meaningful, consistent and valid conclusions. Empirically, the sizes of the correlation coefficients in my analyses based on Pearson's product moment correlations (see Table 7.3.1, and Table 7.3.2) make it unlikely that serious underestimates are occurring. I also used less powerful, non-parametric tests as checks for my statistical tests assuming interval scales or approximately normal distributions. For example, I compared the results I obtained with Pearson's product moment correlations, shown in Table 7.3.1 with Spearman's rank correlations (see Table K, below). Comparing these two tables shows that treating the scores as ranks, that is, as ordinal, rather than interval, leads to Spearman's correlations which differ from the Pearson's correlations by at most 0.04, after correction to two decimal places. Most of the differences are, in fact, only 0.01 or less. I used Mann-Whitney U tests as checks on the t-tests quoted in chapter six and seven, and the Kruskal-Wallis Analysis of Variance, as an alternative to the parametric form of analysis of variance. In every case these produced results of similar magnitude and direction and led me to identical conclusions. I have therefore quoted only the more familiar parametric results. Most importantly, the results obtained are consistent with each other and with the understandings I achieved using qualitative data. They relate to the theory underpinning the research questions.

In summary, as outlined in chapter 4, I present statistical analyses as a heuristic for exploring data and illuminating structures, rather than to prove relationships in a positivist sense. The quantitative analyses serve as a guide to my thinking and qualitative analysis.

TABLE K

SPEARMAN CORRELATION MATRIX FOR CORRELATIONS OF AT LEAST 0.30

(EXCLUDING “NO MEANING” STUDENTS)

	CONCPT	CHOICE (NO 1, YES 2)	DEEP	SURF	CLASS1	EXAM1	CLASS2	EXAM2	PRIOR MATHS
CONCEPT	*								
CHOICE	39	*							
DEEP	36	39	*						
SURFACE	–42	–43	**–42**	*					
CLASS1			36	–35	*				
EXAM1				–33	66	*			
CLASS2				**–30**	68	**61**	*		
EXAM2					62	62	61	*	
PRIOR MATHS		32	**(27)**	**–42**	30	32		33	*
AGE									–32

Decimal points are omitted. Decimals correct to two places.
All correlations statistically significant (p<0.01).
Correlations which differ from those in Table 7.3.1 by more than 0.02 are shown in bold font.

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