Learning Statistics at a Distance

A thesis presented in partial fulfilment
of the requirements for the degree of
Master of Educational Studies (Mathematics)
at Massey University, Palmerston North, New Zealand

Lois Curry

2001

Abstract

There is evidence from many leading statistics educators that students often find statistics a difficult subject to learn. This is often attributed to the abstract nature of the concepts and the change in thinking required to understand the theory of probability and the innate variation existing around us. For mature-aged students, these difficulties may be compounded by lack of basic mathematical skills and anxiety about learning statistics. In addition, learning at a distance may increase the problems students have in obtaining good understanding of the concepts.

The purposes of this qualitative study were to determine the value mature-aged students placed on having a compulsory statistics paper in their business or applied science degree; and to record the difficulties that these students attributed to their choice of the distance mode of learning and their strategies or suggestions for dealing with these. Recommendations for the design of distance courses for mature-aged students were discussed.

The main findings were:

- The lack of mathematical skills was the main reason that students were tentative about tackling a statistics course. Older students and those with little secondary education may be particularly affected.
- Anxiety was not as extensive as had been reported in overseas studies but is still an issue for statistics educators.
- Almost all students saw value in having a compulsory statistics course in their degree and were aware of the need to interpret data presented to them in their study, work or everyday life.
- The mature-aged students demonstrated good metacognitive skills and other learning strategies. Determination to succeed and high motivation were apparent, although many students found the course unexpectedly difficult.
- There was a variety of opinions about the effectiveness of available resources. Support mechanisms were deemed important, as was some face-to-face component in the statistics course and some flexibility in time-frames.

Acknowledgements

There are a number of people without whose assistance this thesis would not have been possible. Most importantly, I wish to thank the students of The Open Polytechnic of New Zealand Statistical Analysis course which was the subject of this study. These students willingly gave of their time to complete questionnaires and participate in interviews and were open and frank about their experiences.

I wish to express my appreciation to my thesis supervisor, Dr Glenda Anthony, College of Education, Massey University. Glenda provided motivation when times got tough and provided valuable input and suggestions for the writing of this thesis.

Thank-you also to my colleagues at The Open Polytechnic of New Zealand, particularly those in the mathematics and statistics section, who shouldered extra workload when time was in short supply.

Finally, thank you to my family for your support and confidence in my ability to complete this project.

Table of contents

List of figures

Chapter 1: Introduction

1.1 Background to the study

Higher education in the 21st century is changing in response to the needs of the population. Increasingly, tertiary students are older and therefore demanding more flexibility in the way education is offered. They no longer have the time or money available to sit in a large lecture hall with a few hundred other students. With the rapid technological advances of the last decade, distance education is increasingly becoming the preferred option for many students as it allows the flexibility of study times and places and a continuity of employment. No longer is distance education regarded as the poor relation of tertiary education. Instead it is seen as a modern option designed to make full use of technology and to fit in with commitments to job, family and leisure activities.

However, some subjects are seen as fitting more comfortably within this scenario than others. Statistics is one of the subjects that presents special challenges to distance educators.

Statistics has always been a difficult subject to learn and Watts (1991) claimed:

> ...the *major difficulty* that confounds beginning students and inhibits the learning of statistics, and that distinguishes statistics from other disciplines such as mathematics, physics, chemistry, and biology, is that *the important fundamental concepts of statistics are quintessentially abstract.* (p. 290)

In addition Simon and Bruce (1991) commented that "probability theory and its offspring, inferential statistics, constitute perhaps the most frustrating branch of human knowledge" (p. 22).

In light of these comments, it is not surprising that a compulsory paper in statistics is often viewed with trepidation by students wishing to complete a business or social

science degree (Diekhoff, 1996, Gal & Ginsberg, 1994). It is also not surprising that Gordon (1995) found that, overwhelmingly, students studying psychology would not study a statistics paper unless it was compulsory. It is likely that this would also be true of many students of business or social sciences. For students who have chosen to complete their degree using a distance education mode, the anxiety may be heightened, since anecdotal evidence suggests that few students would choose to study statistics or mathematics this way, if other options were available. There is a growing body of literature covering research on the way students learn (or fail to learn) statistics in a traditional university setting. However, there is little empirical evidence of the particular problems perceived by students studying statistics in a distance learning environment.

Consideration of the difficulties faced by students learning statistics has important implications. The way the students perceive and deal with (or fail to deal with) the cognitive and non-cognitive issues is of consequence to those designing distance education statistics courses. This is of increasing importance as distance education proliferates with the introduction of on-line learning in many universities throughout the world. Unless these issues are taken into account in the design of distance education statistics courses, the institutions will simply be compounding the difficulties face-to-face students encounter in statistics with those encountered by distance learners.

With the rapid internationalisation of tertiary education, students are no longer restricted to enrolling in a tertiary institution in their country of residence. Universities and other tertiary institutions all over the world are in competition for the tertiary student dollar. With an increasing number of on-line courses on offer, it is apparent that only those institutions which are able to identify and respond to the needs of students, will make a success of technologically enhanced education.

This project attempted to identify the problems associated with studying statistics at a distance. It focused on the experience of a group of mature-age students who were studying a first year statistics paper for a Bachelor of Business or Bachelor of Applied Science degree at The Open Polytechnic of New Zealand. The objective was

to hear their views on the value of learning statistics, to identify any strategies they used for coping with the course and to record their suggestions for improved teaching and support mechanisms.

1.2 Definition of terms

Definitions of distance education are often complex and have been discussed in detail by Simonson, Smaldino, Albright and Zvacek (2000). Although distance education is generally accepted to mean education where the learner is physically separated from the teacher, tutor or lecturer, the precise definition is subject to debate. In the United States the term increasingly means education of a highly technological nature although in the United Kingdom, Australia, Canada and New Zealand, the understanding of distance education is broader, encompassing a variety of delivery methods with emphasis on student support.

Within the literature, the term 'open learning' is also commonly used. This is a philosophy of learning, whereby variation in learner backgrounds is recognized and which has the characteristics of accessibility, flexibility, learner control over content and structure and choice of delivery systems (Paul, 1990). The terms 'distance education' and 'open learning' are not interchangeable – distance education institutions will have degrees of openness, depending on their individual policies.

For the purposes of this research, distance education is taken to mean education undertaken in the student's home and does not include audiovisual classes where the tutor may be at a distance but the students meet together for instruction. Courses offered by The Open Polytechnic of New Zealand mainly fall within this definition. Distance education in New Zealand is predominantly paper-based, although many courses now have some electronic component such as listservs, forums or chat rooms, electronic textbooks, interactive learning materials, etc. The course which was the subject of this project had a set text, a learning guide, an optional video series, an on-line forum and a media activities book; and use of statistical software was an integral part of the course.

Mature-age students are defined, for this project, as those students who are not undertaking tertiary education directly after leaving school. Consequently, only students aged 20 years or older were included. Ninety eight percent of the students enrolled in the course being studied met this criteria and the majority were working full-time.

1.3 The research questions

The overall objectives of this research project were two-fold. The first was to listen to the voices of students studying an introductory statistics paper in a distance education environment and to determine their perceptions of the value of a statistics course in their degree and their attitudes towards studying statistics. These could then be compared with previous findings of research on attitudes and beliefs of students studying statistics in a contact class environment. The second objective was to record the perceived difficulties, if any, that the students attributed to their choice of the distance mode of education for studying statistics and also to record their strategies and suggestions for overcoming these difficulties. The existing literature on learning statistics, summarised in Chapter 2, helped clarify the specific questions to be addressed by the study:

- How do students describe the way they are feeling about beginning a distance-education statistics course?

- What value do beginning students see in a compulsory statistics course and how do they perceive it before and after completion?

- What problems unique to learning statistics by distance education do students perceive? Were these problems successfully dealt with by completing students and if so, how?

- What additional support mechanisms do students perceive as useful?

Chapter 2: Literature review

The relevant literature falls into several categories. Research related to the way students learn statistics and the problems they encounter will be of primary consideration, but it will also be of value to consider the relevant research on the learning of mathematics. Moreover, consideration of the body of literature on distance education and the way students learn at a distance is important, and, as the students participating in this piece of research are all mature-age students, research related to adult learning is also important.

2.1 Literature on teaching and learning statistics

Gunn (1999) has noted that approaches taken in the literature on teaching and learning statistics can be grouped in three partly overlapping areas:

1. Content and context approach. This focuses on the goals of the statistics curriculum and appropriate pedagogy but often makes implicit assumptions about how students learn statistics.
2. Teaching and learning theory approach. This includes work on how students learn statistics and factors that affect their learning.
3. Philosophical approach. This includes discussion of what statistics is, what constitutes statistical thinking and who should teach statistics.

Gunn (1999) argued that there is little work on different ways of knowing (as described by Belenky, Clinchy, Goldberger & Tarule, 1986), cultural dimensions and theories connecting statistics and education. She also argued that, in approaches to design and delivery of introductory statistics course, "what appears to be missing is a holistic view that simultaneously addresses cognitive, affective and volitional issues" (p. 246).

The following review will encompass current literature in all these areas and discuss how the research has impacted on the teaching of statistics in recent years.

2.1.1 Affective issues

Consideration of the affective domain (i.e. issues relating to emotions, values and attitudes) is an issue for all educators. In a study of undergraduate students Entwistle and Entwistle (1992) noted:

> Students repeatedly commented that the experience of understanding generally had a feeling tone associated with it - there was necessarily an emotional response, at least where significant understanding had been achieved. The inseparability of cognitive and emotional components of understanding was very clear in the comments made by students. (p. 7)

Affective issues such as attitudes, beliefs and emotions are of particular concern to mathematics and statistics teachers. McLeod (1992), in considering these issues in the context of mathematics education, distinguished between these three categories. He described emotions as fleeting responses, triggered by immediate experiences; attitudes as stable, intense feelings that develop over time; and beliefs as ideas held about the subject and about the individual's ability to learn it. Gal and Ginsberg (1994) claimed that many students were likely to have trouble with statistics due to non-cognitive factors such as negative attitudes or beliefs towards statistics. They discussed the need to address these issues for two reasons. Firstly, they argued that the issues must be addressed to ensure that a statistics course encourages motivation to learn, confidence in using statistics and a willingness to think statistically. Secondly, they argued that affective and attitudinal factors impacted on the teaching and learning process and may create a learning environment which is not conducive to safe exploration. They noted that research on students' attitudes was more common than that on students' beliefs, but argued for more research on both aspects.

The most prominent of these affective issues in the statistics education research literature is "statistics anxiety", which is taken to mean the feelings of worry or panic encountered by students when confronted with the need to complete a course in statistics or when required to collect or analyse data. Statistical anxiety is something

that is not specific to any one ethnic group, as Bell (1998) and Onwuegbuzie (1999) have shown it is common among both international students and African American students studying statistics in the United States.

While statistics anxiety has been discussed in many papers, Roiter and Petocz (1996) claimed there have been "few definitive studies conducted in this area" (p.1) and "current literature on anxiety does little to provide suggestions that can be easily incorporated into daily practice" (p. 2). Bradstreet (1996) however, noted:

> Simply by asking the students about their concerns at the beginning of a course, and reassuring them throughout a course, a teacher can communicate to the students that he/she is aware of their anxiety and will help them confront and overcome it. (p. 71)

Trying to address the issue of how to deal with statistical anxiety, Townsend, Moore, Tuck and Wilton (1998) showed that using a co-operative learning structure improved students' self-concept but failed to reduce anxiety, suggesting that this is a deeply entrenched emotion and should not be regarded as something that can easily be dealt with.

A second affective issue concerns the perceptions and attitudes a student has about statistics, as Gordon (1993) and others have shown that these will impact on the quality of their learning as their "approaches to learning are mediated by their appraisals of the context and personal value of the educational practices in which they take part" (p. 44).

Predominant among these perceptions is the relationship between mathematics and statistics. Gal and Ginsberg (1994) claimed that students believe that statistics requires quite advanced mathematics and that their experiences of school mathematics may determine the way students approach a statistics course. Bradstreet (1996) also noted that "the connection between the two subjects [mathematics and statistics] in the minds of nonstatisticians is inescapable" (p. 70).

Gordon (1993) found that students starting a statistics course based their beliefs about statistics on their previous mathematics experiences. Despite a reasonable degree of competence in using mathematics in real-life situations, "they expected their university course to be an intimidating, mysterious and difficult subject unrelated to the life skills they had developed" (p. 39). Gordon saw the need to address students' conceptions of mathematics as a first step in providing a suitable environment for enjoyable and successful learning in statistics.

Conceptions of statistics as heavily mathematical, means that in the work of Townsend et al. (1998) and others, much of "statistics anxiety" is thought to be due to "mathematics anxiety". Rather than a fear of doing statistics, many students approach a statistics course with anxiety about coping with the mathematical aspects. The impact of mathematics anxiety has been discussed by Tobias (1993) who argued that anxiety, not lack of ability, stood in the way of otherwise intelligent adults doing well in mathematics. The close links between mathematics and statistics in the minds of students will be a recurrent theme of this thesis.

To avoid this perceived connection between mathematics and statistics, some commentators have argued that statistics should not be taught from within a mathematics department (e.g. H. Roberts, 1996). Box (1990) argued that statistics should be regarded as being about scientific investigation, rather than mathematics, and espoused this view:

> ...the physicist, the chemist, the engineer, and the statistician can never know too much mathematics, but their *objectives* should be better physics, better chemistry, better engineering, and in the case of statistics, better scientific investigation. (p. 251)

Other statistics educators (e.g. Higgins, 1999) have argued that more emphasis should be placed on the non-mathematical aspects of statistics and things like protocol management and data management should be included to give statistics a clear, and less mathematical, identity. It can be argued that these topics may be more useful to society than the more mathematical topics currently included in most undergraduate

courses. Vere-Jones (1995) named three factors which, he argued, may turn out to be as important as the links with mathematics, namely, "...the importance of statistics as a key methodological tool in areas such as the medical and social sciences; its importance in government and politics; and its ethical demands" (p. 15).

However, there is no doubt that statistics as taught in most tertiary institutions today, relies heavily on the use of basic mathematical skills. Even with use of computers to lessen the need for long calculations, basic numeracy is essential for statistics. Tanur (1997) bemoaned the lack of basic skills (such as finding percentages) for her sociology students studying statistics and noted:

> The point is that these students are not innumerate - they are able to use these calculations in their everyday lives, but by and large they are not facile with arithmetic, let alone algebra or statistics and they suffer symbol shock easily. (p. 160)

Yet another factor affecting the learning of statistics is the students' perception of the relevance to their personal lives. In their study of psychology students at the University of Sydney, Gordon, Nicholas and Crawford (1996) found a relationship between the students' conceptions, their attainments in assessment tasks and their willingness to study statistics. More of those who said they would choose to study statistics, than those who were only doing statistics because it was a compulsory paper, saw relevance in what they were learning. Nevertheless, "for most students, a lack of understanding and interest was no deterrent to their successful completion of class exercises nor reflected in grades" (p. 18). In a later paper, Gordon (1997) noted that most 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" (p. 199) and concluded that "students' awareness about their learning links a complex network of individual, social and contextual variables" (p. 192).

2.1.2 Cognitive issues

Among the researchers looking at cognitive issues in studying statistics, Williams (1999), and Gardner and Hudson (1998) have shown that the concepts in a first year statistics paper are difficult to grasp and many students end the course with poor conceptual knowledge and an inability to apply what they have been taught. In addition, Konold (1995) and Pfannkuch and Brown (1996), among others, have investigated misconceptions about probability, and, within the field of cognitive psychology, there is much literature about fallacies based on chance (for example, Fong, Krantz and Nisbett, 1986). Hawkins, Joliffe and Glickman (1992) commented that "it is probably true to say that the transmission of probability concepts to our students remains our greatest challenge" (p. 60). They argued that this may partly occur because the language of probability differs from everyday language. This may help explain why learning statistics is so difficult. Since probability is such an integral part of the topic of inference, the difficulty in making sense of probability acts as a barrier to successful learning of statistics.

Garfield and Ahlgren (1988) also argued that there are many misconceptions about the ideas taught as part of probability theory and noted that it is difficult to change these misconceptions:

> Students' intuitive ideas, presumably formed through their experience, may be reasonable in many of the contexts in which students use them but can be distressingly inconsistent with the statistics concepts that we would like to teach them. (p. 50)

2.1.3 Statistics education reforms

Over the last decade, there have been calls for substantial changes to the way statistics is taught by universities and other tertiary providers. The changes required were summarised by Hogg (1991) who called for an improvement in communication skills of teachers, more encouragement for students working in teams on collection and analysis of real data, and more liaison with business, industry and government.

The reform movement was commented on by Moore (1997). He linked changes in the teaching of statistics to the development of new learning theories and claimed that "the central idea of the new pedagogy is the abandonment of an 'information transfer' model in favor of a 'constructivist' view of learning" (p. 124).

In response to reformers' calls for a change in culture from rigour of detail to the teaching of useful applications, he called for a close look at the skills required by employers:

> Note carefully that it is not at all clear that *statistical* skills in the traditional sense are required. Few people will need to interpret ANOVAs, fewer will need to carry them out, and still fewer will need to understand the details behind ANOVA software. (Moore, 1997, p. 124)

For first year non-statistics majors, Billard (1998) recommended a 'statistics in society' course, engendering an appreciation of statistics, rather than specific methods. Billard saw these courses as reaching future leaders and lawmakers and argued that these courses should be compulsory for all degrees. There has also been calls for teaching statistical reasoning (concepts and thinking) before teaching statistical methods (Bradstreet, 1996; Rossman & Chance, 1999; Wild, 1994). In particular, analysing claims made by media is seen as an important aspect of statistical thinking (Pfannkuch, 1996; Watson, 2000).

Because research (Konold, 1995 and Pfannkuch & Brown, 1996) has shown that understanding probability is complex and difficult, Moore (1997) argued for a lessening in the amount of probability taught and advocated covering only the probability essential for inference. Falk and Konold (1992) and others have expressed an opposing view, while Garfield and Ahlgren (1988) advocated the initial separation of probability and statistics teaching. Sharma (1996), in summarising some of the problems relating to definitions of statistics, probability and stochastics, discussed some of the trends in teaching these topics. She noted that there is a growing emphasis on exploratory data analysis in statistical education conferences

but claimed that statistics and probability are complementary and an understanding of one increases understanding of the other.

However, the reforms described above may have had less impact than Moore implied, since Garfield (1997), in her comment on Moore's (1997) review, claimed "despite the quality of the available materials and resources and the enthusiasm of education reformers, most statistics courses taught in institutions of higher education have changed very little" (p. 138). She noted that the teaching methods had changed little, the students still expressed anxiety and made negative comments about their class while the teachers were frustrated by students' poor mathematics backgrounds and their inability to apply their skills.

In an attempt to improve teaching methods, Garfield (1995) summarised the findings of research which indicated the following ways of helping students learn statistics:

- small group work
- activity-based courses
- corrective-feedback strategies
- making predictions about the likelihood of samples and comparing with reality
- use of computer simulations
- use of interactive software.

The activity-based courses advocated by Garfield (1995) have been heavily promoted within statistics education over recent years and activity-based tasks have been built into textbooks by Rossman (1996); and Scheaffer, Gnanadesikan, Watkins and Witmer (1996). Garfield (1995) however, noted that there is a need for research to determine what specific activities work best in helping students learn particular concepts. The difficulty in using such activities in large introductory statistics courses has been a challenge to tertiary teachers (Wild, Triggs & Pfannkuch, 1997) and, in addition, students do not always perceive the more active approach as desirable. McAlevey and Stent (1999) surveyed undergraduates' perceptions of good teaching in a business statistics course at Otago University and found students preferred a structured approach. Tanur (1997) also noted the preference for a

structured approach and asked the question "how do we motivate our students to learn actively when they consider it easier to be spoon-fed?" (p. 161). Gal, Ginsberg and Schau (1997) attributed this lack of readiness to embrace an active learning environment to attitudes resulting from prior experiences of mathematics and mathematics teachers.

Snee (1993) has argued that students will better see the value of statistics when it is presented in the context of real life problems. However, McAlevey and Stent (1999) found their students placed a relatively low significance to motivation by way of applications and by relating the application of statistics to relevant business areas. The researchers saw this as reinforcing "the complexity of the task confronting the statistics teacher who must walk a fine line between selling the relevance of an often misunderstood and difficult subject and successfully imparting the underlying concepts" (p. 225) and suggested that an introductory course may be too early in a student's study for maximum benefit of using applications to occur.

As a result of the changes outlined above, it became apparent that assessment must change too. Among educators who have addressed this topic are Chance (1997), Garfield (1994) and Hubbard (1997). Chance (1997) discussed the need to assess the students' ability to interpret, evaluate and apply statistical reasoning, rather than the procedural calculations and noted that "assessment should mirror the skills students will need in order to be effective consumers and evaluators of statistical information" (p. 1). Techniques used in her course were a computer laboratory component, a term project with peer reviews and oral presentations, a take-home component to the final examination, minute papers (Mosteller, 1988) and student journals. She argued that these types of assessment were not only effective as instructional and assessment tools but also as motivational tools, thus increasing both learning and retention. Motivation, or lack of it, was also a theme of Hubbard (1997) who argued that many students wish to pass their introductory statistics paper with minimum of effort and therefore focus almost exclusively on assessment. She claimed it was possible to design assessment questions which focused on the goals of the course and distinguished between deep and surface learning as well as motivating the students.

2.1.4 Technology in statistics education

In the last decade, the use of technology in education has expanded rapidly. Bratton (1999) claimed that the impact of technology should be especially strong in the teaching of statistics. He argued that, as the computer is an essential tool for a practising statistician, students should be taught to use them to reduce tedious calculations, to enable use of more realistic data sets and scenarios, to run appropriate simulations and to obtain more precise results. Such a learning environment would "focus on developing fundamental statistical concepts" (p. 2).

As well as statistics software packages being made available to students, there are a number of programs designed to teach statistics at an introductory level (Ganesh & Ganesalingham, 1998). Developments in computers, graphics and videos have the potential to demonstrate the use of statistics in ways undreamt of in the past and to assist teachers in innovative ways. For example, the Open Universiteit Nederland is producing software with embedded support devices (ESD's), to tailor courses to individual students and produce examples relevant to each profession (Valcke, 1998). Thisted and Velleman (1992) commented that, as most students studying basic statistics are majoring in other disciplines, they are more likely to be motivated by learning about the world and that "computers allow a statistics class to consider the complexities of the real world" (p. 45). However, Ferris and Hardaway (1994) claimed that the rate of change in teaching is much slower than the rate of change in technology and commented:

> Technology by itself will not solve educational problems; rather the intelligent and creative development of a multimedia approach may provide an alternative method or a supplement for the more effective teaching of statistics. (p. 5)

Despite the development of technologies, Moore (1997) still saw an important role for the teacher, especially in the areas of motivator, encourager and assessor and claimed that emphasis on multimedia technology neglected the social aspect of learning and the personal presence. The need for a personal approach is evident in

the research of Schuyten and Dekeyser (1998) who noted that students preferred to learn statistics in the traditional lecture format rather than independently in either electronic or paper mode. Bradstreet (1996) also emphasised the need for a high quality relationship between the teacher and the students, noting that without this relationship, no amount of resources will produce a good outcome for the students. However, McAlevey and Stent's (1999) Otago University students gave 'establishing positive relationships with students' a low ranking when asked about the main task of a statistics teacher.

2.1.5 Statistics and distance education

Within the literature on learning statistics, there is very little which discusses distance education as it is known in New Zealand. At the most recent International Conference on Teaching of Statistics, Lunn (1998) discussed the development of statistics courses offered by the Open University and noted that although the technological advances in other institutions were exciting, educators must not lose sight of the needs of developing countries where computer access is limited. At the same conference, Dunning and Lai (1998) examined the use of a mailing list and a telephone help desk for students studying an introductory business statistics paper at Massey University. They saw the need for further research and development to encourage use and provide extra benefits for students learning at a distance.

Although there is much written about interactive software for the teaching of statistics, most of it is being developed to be used in conjunction with face-to-face lectures, tutorials and computer laboratory sessions. However, there are obvious applications within a distance learning environment and there is some evidence that a totally computer based course with interactive software will be well accepted by distance learners (Martens, Valcke, Portier, Weges & Poelmans, 1997). It is yet to be determined whether this will provide the best outcomes for students and Phillips, Francis and Hutcheson (1998) noted that technology can be used to enhance statistics courses but it will not necessarily replace traditional delivery modes. They advocated a multi-modal approach to overcome the disadvantages of any one method and to provide students with a choice to suit their preferences and learning styles.

2.1.6 Summary

In summary, the teaching of statistics has gone through a radical reform in the last decade. The rapid advances in technology have led to a variety of interactive teaching packages becoming available, and while these are generally accepted as enhancing the learning experiences of students, it is not yet clear which features provide the best learning outcomes. Consideration of both cognitive and affective issues have been prominent in research and debate among leading educators over the content of introductory statistics courses continues.

2.2 Literature on teaching and learning mathematics

The discussion of affective issues in the teaching of statistics has shown that there is a close link between mathematics and statistics in the minds of students and the general public. Therefore, it will be useful to look at some of the research literature relating to the learning of mathematics, particularly that relating to affective, motivational and metacognitive issues.

2.2.1 Affective issues

McLeod (1992) reviewed the research on affect in mathematics education and noted that most of the research had not been grounded in a strong theoretical foundation. He saw the need for researchers with an affective orientation to work more closely with those having a cognitive orientation and noted that, although there had been much research in this area, it had not had a major impact on the way mathematics was taught.

Within the broad topic of affective issues, mathematics anxiety has been the subject of a considerable amount of research. In an attempt to quantify the impact of mathematics anxiety, Ho, Senturk, Lam, Zimmer, Hong and Okamoto (2000) undertook a study, based in three different countries. They found that anxiety had a negative relationship with mathematics achievement and claimed that this could

negatively impact on mathematics related activities such as learning statistics. They made the distinction between the affective and cognitive dimensions of mathematics anxiety, finding that the affective anxiety was more detrimental to performance. This negative relationship has been confirmed by the meta analysis of Ma (1999) who found that the relationship was consistent across gender groups, grades, ethnic groups, instruments measuring anxiety and years of publication.

Several researchers have designed and evaluated courses which attempt to address the impact of affective issues on mathematics students. Fiore (1999) discussed how mathematics anxiety could result from bad experiences within mathematics classrooms and referred to students affected in this way as "maths-abused" students. He noted that "preventing and overcoming math anxiety begins with teachers and teaching strategies that develop positive and realistic self-concepts" (p. 4). For older students, who have previously experienced failure in mathematics, innovative teaching approaches using dialogue, reflection, personal relevance and a more supportive environment, have been shown to be successful (Burton, 1987; Patrick, 1999). Patrick (1999) found that as her course progressed, the students' attitudes to mathematics changed, as did their recognition of existing skills and knowledge and that "increased confidence was the main ingredient needed to enable them to learn mathematics" (p. 95).

Within the tertiary sector, Anthony (2000) has shown that students ranked 'self motivation' as the factor having the most important influence on success in a first year undergraduate mathematics course. This was followed by 'study for tests and exams' and 'making sure the basics are understood'. These results were compared with lecturers' perceptions of factors, as it was recognized that both teaching and learning processes influence the learning outcomes. Lecturers agreed that motivation was the most important factor. Crawford, Gordon, Nicholas and Prosser (1998) researched how students' prior understanding of the nature of mathematics related to their perceptions of learning contexts, approaches to study and learning outcomes. This study extended their previous research (Crawford et al., 1994) which showed that most students entering university regarded mathematics as a fragmented body of knowledge, and used repetitive and surface approaches to learning that were related

to the ways students conceived mathematics. These researchers identified two distinct patterns in their 1998 study: they found that fragmented conceptions of mathematics were associated with surface approaches to learning mathematics, perceptions of assessment as measuring reproduction and perceptions that the workload was too high. Alternatively, cohesive conceptions of mathematics were associated with deep approaches to learning mathematics, perceptions of good teaching and clear goals. They urged a more systemic view of the learning environment with more awareness of students' total experiences of learning mathematics.

2.2.2 Metacognition

Metacognition in mathematics learning has been considered by Goos and Galbraith (1996), Wilson (1998) and others, and metacognitive processes are thought to be crucial for effective mathematical thinking. Wilson (1998) reviewed previous literature which attempted to define metacognition (the term first used by Flavell, 1976) and noted that it referred to both knowledge about cognition and regulation of cognition. She concluded that "metacognition refers to the awareness individuals have of their own thinking and their ability to evaluate and regulate their own thinking" (p. 694) but noted that existing definitions are imprecise and difficult to interpret in operational terms. She claimed that suggestions of a link between metacognition and the ability to solve mathematics problems, meant that assessment practices in mathematics should include assessment of student metacognitive thinking so students have the opportunity to develop these ideas.

In Anthony's (2000) investigation into factors influencing first year students' success in mathematics, questionnaire responses showed lecturers placed less importance than students on active attention in lectures and note-taking, indicating that lecturers see the need for reflection and self-directed learning after the lecture. However, in contrast to the student questionnaire responses, interviews with students showed little evidence of active learning in lectures. Anthony suggests that not all first year students have the effective metacognitive strategies to be independent learners.

2.3 Literature on learning at a distance

The discussion above reviewed the affective, cognitive and metacognitive issues within statistical and mathematical education and the reform movement over recent years. Within this literature, the needs of the student studying at a distance have had scant mention. It is therefore important to look at specific literature on learning at a distance and attempt to find areas of research which impact on the learning of statistics.

The debate over definitions of distance education discussed in section 1.2 will be largely ignored in this review. All research discussed, whether falling under the New Zealand definition of distance education or not, has the potential to inform and to assist in the development of distance education courses. Consideration will be given to research ranging from one end of the spectrum, Web-based courses with built in support mechanisms, to the other, traditional paper-based courses. With the exception of two books on Web-based learning, all literature reviewed has been published in books or journals relating to distance education or open learning.

2.3.1 The theory of open and distance learning

Any discussion of the impact of distance education should be done in the context of theory and the models that have been developed to describe distance education and the way students learn at a distance. Simpson (2000) claimed that "there is debate as to whether ODL [Open and distance learning] constitutes a discipline in its own right and consequently whether there can be such things as theories of ODL" (p. 156). However, as distance learning is now taught as a specialist subject in many universities, it seems important to acknowledge the substantial amount of literature setting a theoretical framework. Amundsen (1993) has outlined some of the theories and models relating to distance education but Sauve (1993) noted that "...there are a number of theories and, more exactly, a number of models relating to the practice of distance education, but no overarching theory or concept of distance education" (p. 101).

Among the leaders in developing distance education theory are Otto Peters; Borje Holmberg, Desmond Keegan, Randy Garrison, Michael Moore, and John Verduin and Thomas Clark (Amundsen, 1993). Most of these authors have worked in the field of distance education for a number of years and over this time their models have evolved into a variety of theoretical frameworks. Sauve (1993) claimed that most theoretical models could be grouped into two large fields of study – firstly, those that analyse distance education based on the notions of student autonomy and independence (e.g. Moore, 1986, Verduin & Clark, 1991) and secondly, those that analyse distance education based on notions of interaction and communication (e.g. Garrison & Shale, 1990; Holmberg, 1995). In addition, there are a few frameworks which do not fall into either group, such as Peters' (1998) "theory of the industrialization of teaching" and Keegan's (1993) "reintegration of the teaching act" theory. More recently Simonson, Schlosser and Hanson (1999) discussed "Equivalency Theory" which is based on the notion that learning experiences for distant learners should be equivalent to those of local learners and relies on the use of interactive telecommunications systems.

Over recent years there has been decreasing reliance on the word 'distance' as more attention is paid to the educational aspects of the subject and concurrently there has been a blending of methods between distance and conventional deliveries (Amundsen, 1993). The influence of technological advances on these models has been apparent and Sauve (1993) noted:

> Distance education is still an evolving field and will probably stay this way for a long time since each technological change (aren't we limited by distance that can only be lessened by media?) forces us to re-examine the practice and the theoretical foundations of distance education. (p. 105)

One of the better known recent models relating to distance education is Kember's (1995) model of student progress, shown in Figure 1. The model suggests that entry characteristics such as educational qualifications, employment status etc., influence adult students to proceed along one of two pathways – either social and academic

integration or a less successful path leading to poor results, as measured by the Grade Point Average or GPA. At some point students must undertake a cost benefit analysis to see if it is worth continuing. If they decide to do so, the experiences of the first cycle may enable a more favourable outcome. If the benefits do not outweigh the costs, the student will drop out. This model has implications for the organization of distance education courses, teaching approaches, student support and counselling aspects. While having some useful aspects, this model fails to highlight the complex relationships between the components, often observed in distance education. For instance, it is common to find a socially and academically integrated student forced to withdraw from a course because of an unexpected event. In this case, the cost/benefit analysis occurs before the assessment, a pathway not shown in the model.

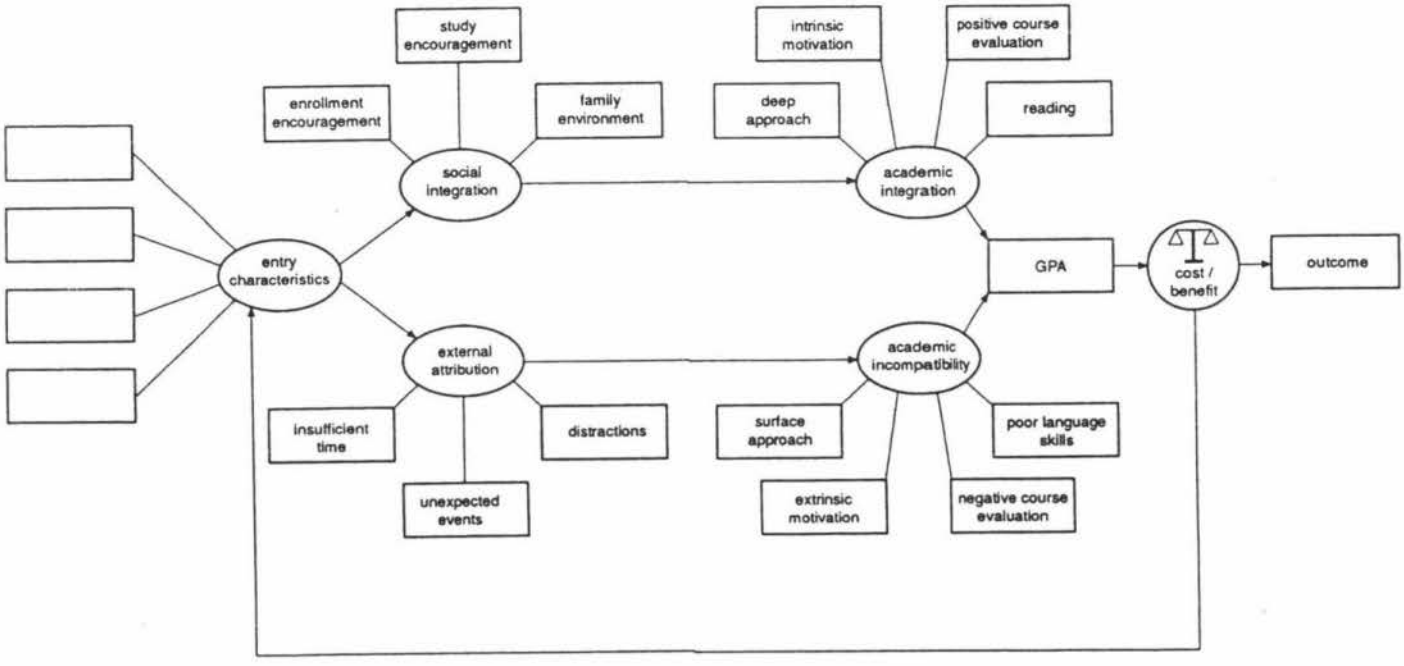

Figure 1: Kember's Model of Student Progress

2.3.2 Constructivism in distance education

The reform movement within statistics has been largely based on a social constructivist approach to learning, whereby learners actively construct their own meanings, building on their prior experiences and knowledge, with the teacher taking on a role of guide and motivator. Within the literature, there has been much debate over whether this style of learning and teaching can be adequately delivered by distance educators. Beaudoin (1990) argued that there are essentially two views of distance education: one describing it as prescriptive and creating dependency, the other arguing that it promotes autonomy and encourages self-directed learning. Constructivism within a distance learning environment has been considered by Garrison (1993), Jonassen, Davidson, Collins, Campbell and Bannan Haag (1995), Kember (1994) and Young and Marks-Maran (1998) among others; and Kanuka and Anderson (1998) claim social constructivism is "currently the most accepted epistemological position associated with on-line learning" (p. 60). Jonassen et al. (1995) argued that a constructivist approach can work well in distance education settings when supported by a variety of computer-mediated communication technologies. However, they also noted that "too often, potentially interactive technologies are used to present one-way lectures to students in remote locations" (p. 7).

There are two features of a social constructivist approach to teaching which may be problematic to both distance educators and students alike. Firstly, an integral component of this approach is the use of small group activities. These develop communication, team-building and interpersonal skills, much valued in today's workforce and enhance students' deep learning as they negotiate a shared understanding with their peers (McAlpine, 2000). In the past, this process has been difficult for students learning at a distance. However, with the advances in computer mediated communications (CMCs) it is now possible for geographically dispersed students to work in groups (for example, Seaton, 1993; Stacey, 1999). Small group work within statistics has been widely promoted by, among others, Bradstreet (1996), Garfield (1995) and Moore (1997). It is thought to provide good training for

professional careers where communication with statisticians and team work to solve problems is widely used.

Secondly, and closely related, a social constructivist approach to teaching encourages articulation of problems and solutions (de Corte, 1995). Garrison and Shale (1990) noted that "improving the quality of the educational process through increased two-way communication is likely to have the most significant impact upon the effectiveness of learning" (p. 128). Advances in technology such as Web-based chat groups, now allow distance students to communicate with each other and to develop a 'community of learners'. These mechanisms can allow discussion on aspects of the course being studied in keeping with a social constructivist approach but may be more effective for senior students as Seaton (1993) commented that "students who are cognitively immature are not as likely to be active participants in CMC learning situations" (p. 51). They may also be more applicable for some subject areas. It is also debatable whether communication by electronic means can ever obtain the interaction that proponents of constructivist teaching initially visualised. Without eye contact and with restricted body language, computer mediated communications are quite different from face-to-face communications. It should also be noted that Burge and Haughey (1993), Garrison, Anderson and Archer (2001), Kanuka and Anderson (1998) and Maher (1998) all argued that the implications for learning using technologically enhanced communication means are not fully understood.

2.3.3 Metacognition and affective issues in distance education

Metacognition "is thought to be an important factor in the acquisition of higher order intellectual skills such as problem solving, decision making and critical thinking." (Young & Marks-Maran, 1998, p. 31) and therefore is an important factor to be considered in statistics education. White (1999) studied metacognitive issues among distance learners of languages and found marked diversity in the metacognitive knowledge of students. In this learning context, "affect emerged as an integral component of metacognitive knowledge and experiences, and the ability to control and harness affective reactions was identified by students as critical for success" (p. 37). In a previous study, White (1997) found distance students reported much greater

use of metacognitive strategies compared to classroom learners, especially with regards to self-management, advance organization and revision. White concluded from these studies that:

> There is a role for orienting students to distance learning in terms of fostering their understanding of the process: in particular it is important that they recognise that the development of metacognitive knowledge is recognised as an integral part of the experience of most distance learners. (White, 1999, p. 44)

Studies of affective issues among distance students have shown high levels of anxiety which may impede their learning (Jegede & Kirkwood, 1994). In their study of distance students at The University of Southern Queensland, Jegede and Kirkwood found that content of study materials, finance and readiness were the top three factors which were perceived as affecting students' learning at a distance. It is also noteworthy that they found the variables of age, marital status and course of study were significantly related to students' opinions about studying at a distance but not significantly related to students' anxiety. However, relatively small numbers (222 students completed pre- and post-semester questionnaires) may have obscured any differences in anxiety attributable to course of study, such as mathematics or statistics. Jegede and Kirkwood saw the need to continue research into the effect of anxiety and factors which affect learning at a distance to determine the role these issues have in attrition rates.

2.3.4 Delivery modes in distance education

There is a considerable amount of research which compares one delivery system with another. For example, Maher (1998) examined how the medium of delivery affects student learning in an audiographics class compared with a face-to-face class. Most research of this type has found little or no difference in the outcomes (Machtmes & Asher, 2000), but Smith and Dillon (1999) argued that this does not necessarily mean that the type of delivery does not impact on learning and suggests that these studies can help our understanding of distance education. Cobb (1997) also argued that

media choices are often about cognition and learning and it is necessary to match media resources to target audiences. Kirkwood (1998) added that "educators need to consider how the technologies can be used to enhance teaching and the experience of learning" (p. 229) and argued against using technologies to replicate the classroom experience. Instead he saw their use as creating a different, but equivalent, learning experience, especially if the desired outcomes and the underlying educational processes are central to their design. In contrast to this, Navarro and Shoemaker (2000) found that CD-ROM-based lectures that simulated the traditional classroom experience were regarded as being the most essential and the most enjoyable feature in a cyberlearning environment.

While computers are most commonly used for communication between students, or between students and tutors, they are increasingly being used to deliver whole courses on-line. As with technologically enhanced communication, many educators have questioned the amount known about the pedagogical basis on which these courses depend (e.g. Reeves & Reeves, 1997). Research has shown that the benefits can include convenience, increased motivation, access to current and global information, and increased understanding through interactive and virtual reality features, while barriers can include lack of appropriate software and lack of technical support for both students and teachers (Daugherty & Funke, 1998). Technological issues such as speed, cost and access need to be considered in conjunction with pedagogical issues such as choice of medium, information overload and possible lack of overall cohesiveness (Hill, 1997).

Chen's (1997) evaluation of five technological distance delivery systems considered four pedagogical issues, namely, interaction between students and teachers; instructional strategies; motivation; and feedback / evaluation. Chen argued that the instructional implications of the delivery systems should be considered carefully before they were selected for a course and concluded that "the strengths of distance education reside in the appropriate selection and choice of a precise mix of distance technologies" (p. 37).

Although Maher (1998) claimed that the literature comparing distance education with traditional instruction does not "examine factors which students perceive to be affecting their learning" (p. 27), recent studies of students' perspectives of learning in technologically enhanced distance environments have been done by Burge (1994) (post-graduate education students), Daugherty and Funke (1998) (technology and health science students), Hildenberg and Tolone (2000) (post graduate education and nursing students) and Petracchi (2000) (social workers).

2.3.5 Student support in distance education

Within the New Zealand context, student support has traditionally been a vital component of distance education. Despite the vast amount written about student support within the distance education environment, Rumble (2000) noted that there "is surprisingly little hard knowledge about what works, and why" (p. 233). He saw a renewed interest in student support as being driven by concern over student dropout and increased competition for the student dollar and suggested that much can be learnt from the service management sector.

Simpson (2000) claimed the reasons for striving for high quality student support fall into three categories: practical reasons (increasing retention rates and attracting new students in the face of increasing competition); theoretical reasons (overcoming isolation by dialogue and reducing the authoritarianism of pre-packaged materials) and finally moral reasons (an implied contract between students and the institution to help students make progress with their studies).

In all three categories, the needs of the student should be of primary consideration. In this context, Tait (1995) noted that "in constructing student support services the key task is to acknowledge the identity of the learner, complementing the mass-produced teaching materials which by virtue of their nature, and as a condition of their effectiveness, are unable to do" (p. 234). Bailey, Kirkup and Taylor (1996) also noted the importance of individualising the process for the learner, seeing support as "humanizing the institution and in helping the student to 'bond' with it" (p.141). Within the literature on student support there is considerable support for the notion of

asking the students what types of support can best assist them (Evans, 1994; McCahon, 2000; Tait, 1995). Various authors have grouped support services in different ways but the three broad categories described below seem the most appropriate in the context of the current study.

Academic support

Simpson (2000, p. 6) attempted to define the scope of academic support, claiming that it included defining the course territory, explaining concepts, exploring the course, providing informal and formal feedback, developing learning skills, chasing progress and enriching the course. The most predominant of these in the literature is providing feedback; although D. Roberts (1996) claimed that the skill of providing good feedback is undervalued in reality. His survey of Open University students revealed that many students anticipated that different feedback would be required for different disciplines, a finding of significance for the current study. Roberts' main findings were that students thought that feedback should be honest but encouraging, that it should clearly indicate how students could improve, and that it should be fast. Speed of feedback was also considered by Inglis (1998) who claimed "the value of feedback in human learning is partly a function of the promptness with which it is supplied" (p. 344).

The cognitive aspect of academic support is also vital. Tait (2000) claimed that the cognitive function of student support is less often recognized than administrative support and noted that "where the support of students mediates teaching embodied in courseware, then it clearly relates to learning, and thus to cognitive outcomes" (p. 289).

Academic support can also include addressing affective issues, i.e. providing an environment in which a student feels motivated, confident and ready to learn. To do this the academic staff may be required to help a student develop their metacognitive knowledge and act as a counsellor when the student experiences a crisis in their personal life.

Advice on programmes and courses can also be included within the broad label of academic support. Mills (1999) noted that with the increasing choice of institutions and modes of learning, the provision of this type of professional advice is likely to become a key measure of quality.

Systemic support

Systemic support relates to non-academic support, including all enrolment and administration functions. The point of first contact is important as students often have difficulty identifying and reaching the right person to speak to (Moore & Kearsley, 1996).

With the expansion of technology in distance education, there is a need for technological support for both students and tutors. Maher (1998) found that technology was the predominant factor which had negatively impacted the learning experience in an audiographic class and that over half the concerns related to faulty or improper use of the equipment. Similarly Navarro and Shoemaker (2000) found that at least 20% of their cyberlearners were concerned with the frequency of technical problems.

Social support

A third type of support shown to be important to students (Gillis, Jackson, Braid, MacDonald & MacQuarrie, 2000) is social support and Garrison and Shale (1990) noted that "distance educators should address not only cognitive but also social needs" (p. 129). Whether in face-to-face gatherings or by electronic means, students need to talk about their lives and studies among themselves to dispel the feelings of isolation that distance education may engender.

Social support can also include support from family, employers and friends. In her survey of Library Studies students, McCahon (2000) noted:

> The contribution of home, work and family in providing support is likely to have a profound effect on the social integration of students – their ability to manage the many roles of their adult lives with the demands of study. (p. 32)

Kember (1995) found that academic and social integration of students were equally important in adult distance education success. He claimed that successful learners become socially integrated by negotiating support for their study time and resources from their employer, co-workers, family and friends. Kember saw this as allowing them to take direct control and responsibility for their studies.

2.3.6 Women in distance education

Among the literature on student support there is some evidence that support for women students may need to be different from that for men. Despite May's (1994) contention that "it is crucial to consider the feminist ramifications of distance education in order to enhance understanding of women distance learners" (p. 82), the published literature relating feminist theory to an analysis of women studying at a distance is a relatively recent development. Burge (1988a) noted that "while talk about women distance learners and educators has been plentiful, writing and research has not" (p. xi), and since then the literature has been sporadic. Burge and Lenskyj (1990), Coulter (1989), Grace (1991), Hipp (1997), Kirkup and von Prummer (1990) and May (1994) have all looked at women's experiences as distance learners. May (1994) claimed that distance education was "a significantly different experience for female learners than it is for male learners" (p. 81) and Kirkup and von Prummer (1990) showed that women learners' preferences are often for collaborative and connected experiences. This last piece of research threw doubts on the previously common view that distance learning was particularly suited to women, as they are predominantly responsible for household management and childcare (Kirkup, 1996) but also, more recently, gave support to the notion that computer mediated communications would have particular benefits to women students. Although May (1993) argued that collaboration in education was a fundamental feminist principle, her research showed that some women students had reservations about the value of

increased collaboration (by phone or teleconference): "Group interaction was considered an impediment to the extent that it was thought to be superfluous, to slow down individual study progress, and to inhibit personal experience" (p. 42). May concluded that busy women need to be persuaded of the benefits of collaborative learning, while institutions need to support a variety of collaborative activities.

Hipp (1997) looked at the support services women distance students needed and concluded from surveys and interviews that the main issues related to confidence, overcoming isolation and connected teaching. The idea of connectedness in knowing arose from the work of Belenky et al. (1986) whose book *Women's ways of knowing: the development of self, voice and mind*, explores the way women view reality and draw conclusions about truth, knowledge and authority. Their findings were based on extensive interviews with 135 women of different ages, ethnicity and backgrounds. Their model groups the women's perspectives into the five categories of silence, received knowledge, subjective knowledge, procedural knowledge and constructed knowledge. Connected knowing was a name given to one of the two types of procedural knowing and is in contrast to separate knowing. A connected knower builds on personal experiences and questions the circumstances that lead to a perception of knowing. This theory has been useful in understanding women's alienation from some subjects and their different styles of communication (Kirkup, 1996). Over recent years, implications of this work has been discussed with relation to learning mathematics (Becker, 1995; Erchick, 1996; Ocean, 1998), but as yet not in relation to learning statistics (Gunn, 1999). Ocean (1998) claimed that "a Connected Knowing approach to mathematics is concept-based and creative, and places the emphasis on co-operation rather than competition" (p. 428).

Another issue for women students is the increased use of technology. O'Rourke (1999) considered women's experiences with learning technology in relation to issues such as access, affordability, trust and privacy and the value of social and co-operative learning. She urged caution in the development of new technologies:

> Gains made by distance educators and feminist educators in enabling more holistic experiential approaches to learning could be

> threatened if new technologies preclude that which cannot be easily transmitted in a crisp comment in an electronic conference, or presented on a web page. (p. 107)

In particular she noted the tendency for institutions to cut back on student support in times of economic tightening, but continue to invest in new technology.

2.3.7 The role of the teacher in distance education

The role of the teacher in a distance learning environment has been considered by Beaudoin (1990), Lentell (1995) and Moore and Kearsley (1996). Ironically, Beaudoin (1990) claimed that off-campus tertiary students are much more likely to develop a productive one-to-one relationship with a teacher than an on-campus student. He saw that the role of a distance educator may be quite different from a normal faculty role and may require different skills. Lentell (1995) argued that it is incorrect to think that distance education minimises the role of the teacher. She wrote:

> Indeed, distance education has enabled the tutor to concentrate on the very heart of teaching itself: support, enthusiasm, encouragement, empathy, demonstration, explanation, clarification, goal setting, assessment, feedback, correction, grading and vision. In short, tutors try to make the course meaningful. (p. 439)

Lentell also argued that tutors have the potential to improve student support services and student learning but that institutional barriers discouraging action research often prevent this.

2.3.8 Summary

In summary, the literature on learning at a distance, describes a burgeoning industry, only beginning to take full opportunity of the rapidly advancing technology. Computer mediated technologies have the potential to allow collaboration and social

interaction as described by a social constructivist theory of learning, but only if they are designed with a strong educational theoretical base. Within this field, the one-to-one support by tutors and programme co-ordinators is seen to be essential. Academic staff must take into account the diversity of their students and address such issues as affective concerns, different learning styles, the needs of women and metacognitive knowledge. Willis (1994) provided the key when he stated that "the importance of personal contact and relationship building remains a critical component of most effective distance education programs and is likely to increase as technical capabilities expand" (p. vi).

2.4 Literature on teaching and learning of adults

In the context of this study of teaching statistics at a distance, research into the way adults learn has important implications. Within the literature on adult learning, the diversity of learners is a common theme. Evans (1994) wrote that "...it is practically impossible to understand *the learner* at all. Rather it is a case of understanding *learners* as a diverse, heterogeneous and changing body of people" (p. 123). While not disregarding this comment, it is still useful to look at what the research literature has shown about the characteristics of adult learners.

The best known philosophy of adult learning is Knowles' (1998 and earlier) work on andragogy, a term which, over the years has been extended into the broader term of learner-centredness (Burge, 1988b). This theory characterizes differences between adult and children learners in terms of self-direction, experience, developmental readiness and problem orientation. He argues that the key characteristics of adults are that they are self-directed, they have a problem-centred orientation to learning, they are internally motivated, they use their life experiences as a rich resource for learning and their readiness to learn develops from life tasks and problems (Bullen, 1995). However, Pratt (1993) claimed:

> While andragogy may have contributed to our understanding of adults as learners, it has done little to expand or clarify our understanding of the process of learning. We cannot say with any

> confidence that andragogy has been tested and found to be...either the basis for a theory of adult learning or a unifying concept for adult education. (p. 21)

In addition, not all research supports Knowles five assumptions about adult learners (Bullen, 1995); and Burge (1988b) argued that not all adults prefer an andragogical approach to learning, noting that life experiences may act as a hindrance for some learners. However, much research does support the five assumptions. Newstead, Hoskins, Franklyn-Stokes and Dennis (1997) have summarized research relating to the motivation of mature students and concluded that adults generally perform well in higher education and are more intrinsically motivated than younger students. Nunn (1998) confirmed this finding and suggested motivation may be a learned social process, influenced by experience. In addition, Newstead et al. (1997) suggested that mature-age students were no more likely than younger ones to drop out due to academic reasons but may be more likely to drop out due to personal reasons, although they acknowledged the evidence for this was weak.

Merriam's (2001) recent comment on adult learning theories noted that andragogy and other approaches which appeared in the 1970s, such as self-directed learning, continue to promote discussion and research and guide the understanding of how adults learn, while more recent theories such as transformational learning, situated cognition and postmodernism place more emphasis on the context in which learning takes place. Some of these influences are apparent in the following research projects.

Rogers (1993) has discussed implications for teaching arising out of a long-term project into the way adults learn. By constructing learner maps, he has identified the following principles which are in keeping with the findings of much research into adult learning:

- Learners come to a new subject already possessing an image of the subject and views about it.
- Each learner will see the subject differently due to prior experiences and expectations.

- More effective learning takes place if appropriate language and symbols are used and concrete examples relevant to the everyday lives of the learners are used.
- It is necessary to know what the learners know about their chosen subject, how they feel about it and what they perceive as its value to them.

By reviewing existing research, Richardson (1997) sought to dispel some myths about adult learners. Firstly, he claimed that the research shows that adults make more use of time-management strategies than younger students, thereby dispelling the myth that they are deficient in effective study skills. Secondly, he identified research showing a consistency in the idea that adults are more likely than younger students to show a deep approach to learning and finally, he found no evidence that mature students under 60 years old were in any way less able to learn new subjects than younger people.

More recent research also supports these findings. For instance, Li, Lee and Kember (2000) found that "there was a marked contrast between the degree of self-management of learning of typical novice students and the learning behaviour of the more experienced students" (p. 25).

The idea of 'deep' learning, mentioned by Richardson (1997) above, refers to approaches focusing on meaning and understanding, as opposed to 'surface' learning which focuses on reproduction. Rather than use the word 'deep' with respect to learning, Taylor (1996), in his qualitative study of undergraduate students, preferred the term 'adaptive' and noted that "the most academically successful students were those who were most reflective about and flexible in their approaches to learning" (p. 234). Taylor also noted that successful students "had highly developed strategies that were closely aligned with their motivation to achieve excellence in their learning outcomes" (p. 234).

Support for the above findings is also provided by Hartley and Trueman (1997, p. 174) who summarized a series of studies of academic performance of adult students compared with younger students between 1975 and 1996 and found:

- the older students usually perform as well as, or sometimes better than, the younger ones;
- the results are sometimes affected by the nature of the discipline with most students – mature or otherwise – doing better in the arts and the social sciences than in the sciences;
- there are sometimes gender differences in the results, but these are not wholly consistent; often mature women seem to do better than mature men but this is not always the case; and
- there is some suggestion that older mature students do not do as well academically as younger mature ones, but the evidence for this is weak.

The use of technology can be an issue for adult learners. Lyman (1999), in considering what Web-based learning can offer an adult student, has devised the following Model of Situated Learning.

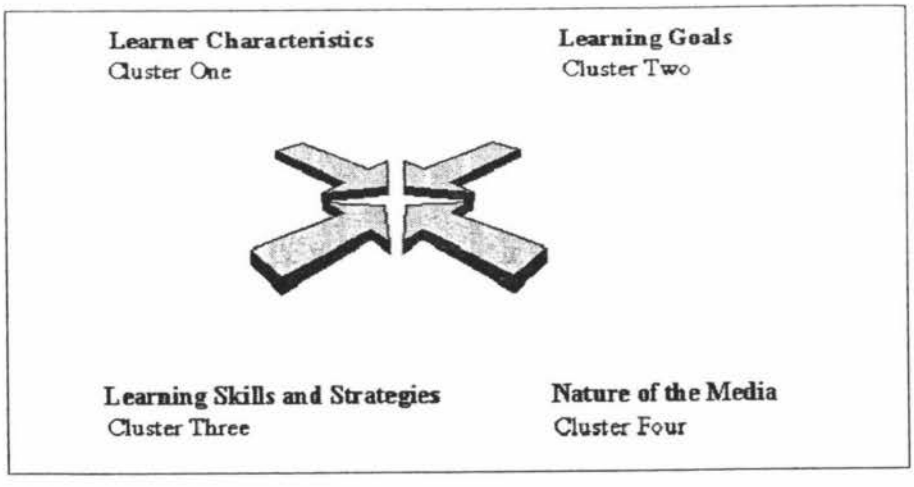

Figure 2: Lyman's Model of Situated Learning

This model groups the factors critical to design and delivery of Web-based courses into four categories which may overlap and which interact within any learning environment. In cluster 1, Lyman saw the extensive prior knowledge that adults often bring to the learning experience as critical to the learning of new knowledge and also acknowledges the diversity in learning styles and the impact of previous negative educational experiences. In cluster 2, she argued that the learning needs of adults differ, based on prior knowledge, experiences and motivation and therefore the learning goals should be flexible. These differences should be respected when considering the design and delivery of learning materials. Cluster 3 included such issues as the need to teach adults navigational skills, database, word processing and spreadsheet use and presentational skills. She noted that:

> As this chapter was being written, little systematic attention could be found in the literature, both on and offline, concerning development of learning skills and strategies required for, or particularly appropriate in, an Internet-based learning environment. (Lyman, 1999, p. 115)

In cluster 4, she noted that, although the internet's advantages as a learning medium are considerable, there may be barriers such as cost, navigational skills and computer-phobia.

This model has been included because, although, it was designed as a model for Web-based learning, it has wider implications for mixed mode delivery courses, such as the one under consideration in this study. It incorporates all of the above findings on adult learning and stresses the interaction of the categories. This model will be used in the discussion of results of this study.

A second model that has relevance to the current study is the Model of Learning in Context (Ramsden, 1992) shown in Figure 3. It shows how approaches to learning are connected to students' perceptions of the context of learning:

> Perceptions of assessment requirements, of workload, of the

effectiveness of teaching and the commitment of teachers, and of the amount of control students might exert over their learning, influence the deployment of different approaches, which are very clearly adaptive responses to the educational environments defined by teachers and courses. Students' perceptions are the product of an interaction between these environments and their previous experiences, including their usual ways of thinking about academic learning. (Ramsden, 1992, p. 84)

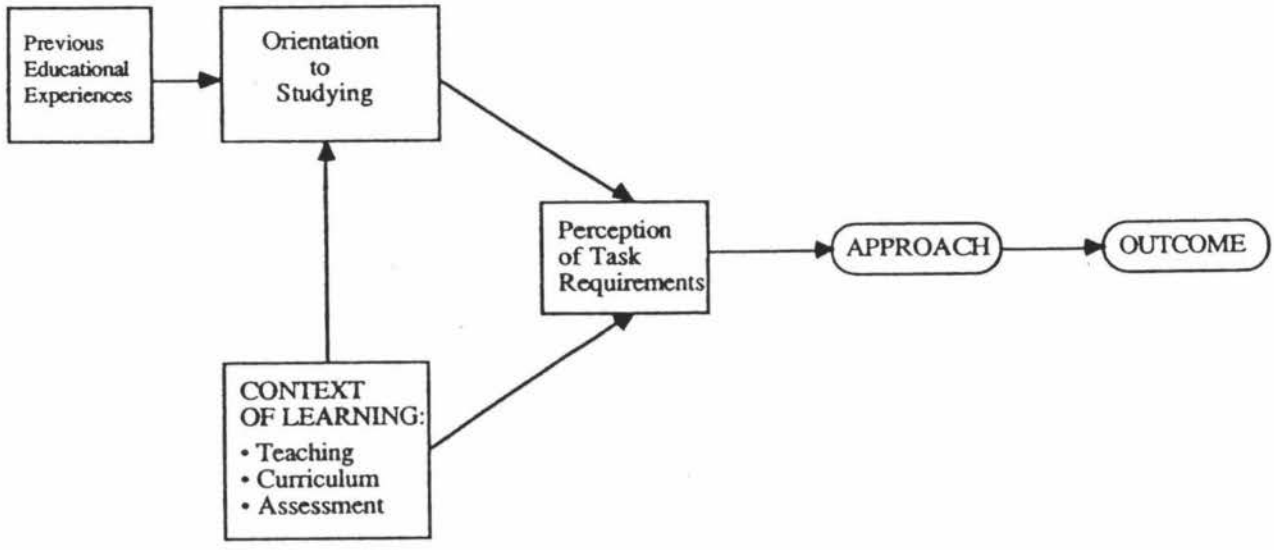

Figure 3: Ramsden's Model of Learning in Context

This model suggests that the quality of learning is influenced by the student's approach (deep or surface) which in turn is influenced by their perception of the task. Both orientation to learning and teaching processes are influential in these perceptions. This model clearly shows that some factors influencing perceptions will be under the control of the teacher, but many others will not. Only by considering the interaction of all factors, will a complete picture of the learning environment emerge.

Finally, there is a small amount of literature on mature-age students learning statistics or mathematics. Leder and Forgasz (1998) found that, compared with school leavers, fewer mature-aged students were studying mathematics because they

believed they were good at it. They found that mature-age students rated university mathematics as being more enjoyable, challenging, interesting and well-taught than school leavers and also that they attributed likely success to hard work. Surprisingly, they found no differences in perceived levels of competence with computers or calculators.

Only one paper relating to mature-age students studying statistics has been found. Gordon (1993) has explored the approaches to learning of a small group of mature students studying statistics, from an activity theory perspective. Her interview data showed a range of beliefs about mathematics and a diversity of perceptions of the learning context and she claimed the students' awareness of the meaning of their own experiences and environment was at the core of their learning. In relating the findings to improving the teaching of statistics, she suggested the role of the teacher is to guide students to view their learning as relevant and meaningful rather than transfer a body of knowledge. To do this effectively "the implicit assumptions underlying the content, presentation and evaluation of the course need to be examined in the light of the students' perceptions" (p. 45). She concluded, "in short, in order to negotiate a shared view of statistics with the learners, the educator needs first to understand the nature of the activities, mediated by personal and reflective aspects, in which the learners are engaged" (p. 45).

2.5 Summary

This literature review has summarised the research into learning statistics, the reforms in statistical education, the affective and metacognitive issues in the learning of mathematics, the literature on learning at a distance including technology issues and finally the research on adult learners. It provides a wealth of background information in which to situate the issues of how learning statistics at distance is perceived by students and what specific support mechanisms are required for students who choose to learn this way. This study will attempt to provide some answers to these questions.

Chapter 3: Methodology

3.1 Justification for methodology

Just as the literature review helped clarify the research questions, the research questions now provide indicators of the appropriate choice of research methodology. After consideration of a variety of research methods, it was decided that a qualitative approach would be most suitable to provide data which would assist in answering the research questions. Qualitative research has been described as "a form of inquiry that explores phenomena in their natural settings and uses multi-methods to interpret, understand, explain and bring meaning to them" (Anderson, 1998, p. 119). Unlike quantitative methods, which are supported by a positivist or scientific paradigm and based on the assumption of the world being made up of observable, measurable facts, qualitative methods are supported by an interpretivist paradigm. This alternative paradigm describes "a world in which reality is socially constructed, complex and everchanging" (Glesne & Peshkin, 1992, p. 6). The qualitative approach provides the flexibility needed to explore this complexity.

Merriam (1998) claimed that the key concern of a qualitative researcher is to understand from a participant's perspective: "Qualitative researchers *are interested in understanding the meaning people have constructed*, that is, how they make sense of their world and the experiences they have in the world" (p. 6). Because of this, and because the research questions in this study focus on hearing the voice of the student, this approach was deemed the most appropriate to access the perceptions, interpretations and feelings of the students, independently of pre-existing perceptions the researcher may have held.

There is support in the literature previously reviewed for such a qualitative approach. Among the distance education literature, Evans (1994) noted that support services for students should be driven by students' individual needs: "The challenge is to develop and maintain approaches which enable students to have their voices heard and for the open and distance educators and their institutions to be able to listen and understand

the practical implications of what is being said" (p. 128). Burge (1988b) also noted that:

> If the production of knowledge about distance learners, learning processes and tutoring strategies is to develop beyond experimental methods, it will do so through the greater use of methods that focus on how learners perceive and interpret their realities. (p. 7)

Similarly, but from a feminist point of view, Hipp (1997) argued that "in order to ascertain the sorts of education and support appropriate to women's needs it is necessary to understand and know more about their experiences" (p. 48).

There is also support for qualitative research in the literature on learning statistics. For example, Gal and Ginsberg (1994) reviewed two surveys designed to assess attitudes towards statistics, the 'Statistics Attitude Survey' (Roberts & Bilderback, 1980) and the 'Attitudes Towards Statistics' survey (Wise, 1985). While they noted the need for statistics educators to be able to assess students' attitudes and beliefs, they concluded that the current assessment instruments, which use Likert-type scales reveal little useful information:

> Especially when it comes to mathematics or statistical anxiety, which may negatively influence students' interest, motivation, and comprehension, it appears that Likert-type scales have very limited usefulness for identifying what individual students are anxious about, their beliefs about learning statistics that might be counter-productive, and what types of support or educational experiences might be useful for students. (Gal & Ginsberg, 1994, p. 9)

They saw the need for inclusion of open-ended questions, structured interviews or focus group discussions to provide better understanding of the factors affecting learning.

A more recent instrument is the 'Survey of Attitudes Towards Statistics' (Schau, Stevens, Dauphinee & Del Vecchio, 1995). But again, it has been argued (Gal, Ginsberg & Schau, 1997), that it has not been designed to provide information about causal factors or the sources of attitudes and beliefs and that there is a need for more research about students' beliefs and more development should be done on the assessment instruments.

The most prominent qualitative research in the statistical education field is Gordon's (1993, 1996) research on students studying statistics at the University of Sydney:

> The use of a phenomenographic approach to this research has allowed us to describe the experience of learning statistics at university from the point of view of the students themselves. We have attempted to give our students a voice, a voice not normally heard in statistical education. (Gordon, Nicholas & Crawford, 1996, p. 12)

With these comments in mind, a qualitative approach was selected, as the researcher sought to understand the experience of learning statistics at a distance from the perspective of the learner. There are, however, some difficulties with using a qualitative approach. Merriam (1998) noted that as the qualitative researcher is the primary instrument for gathering and analysing data, they can maximise opportunities for collecting and producing meaningful data. However, this strength can also be a weakness as "[the] human instrument is limited by being human – that is, mistakes are made, opportunities are missed, personal biases interfere" (Merriam, 1998, p. 20). Burns (1996) also noted some limitations – the difficulty in applying conventional standards of reliability and validity, the time required for data collection, analysis and interpretation, the reactive effect caused by the presence of the researcher on participants and increased ethical considerations. Some of these issues will be considered individually later in this section.

3.2 The Course

The students involved in this research were all mature-age[1] students, resident in New Zealand and enrolled for The Open Polytechnic of New Zealand course 72160, Statistical Analysis. This is a first year (level 5) statistics paper and runs over one semester (17 weeks). It is a core paper for The Open Polytechnic Bachelor of Business degree and Bachelor of Applied Science degree (majors in marketing, information systems and technology, psychology, information and library studies). The Open Polytechnic of New Zealand is a leading provider of distance education in New Zealand and is very experienced in providing user-friendly materials to students throughout the country and abroad. The course, Statistical Analysis, is primarily print-based but has an electronic forum, and videos and interactive learning materials on the internet are optional extras. The use of statistical software is an integral part of the course.

The text book used for the course is Moore and McCabe (1999), *Introduction to the Practice of Statistics*. This book comes with a CD-ROM which contains quizzes, interactive demonstrations, data sets and video clips. A media activities book accompanies the CD-ROM and leads students through the activities. The set of videos, *Against all Odds* (1989) is available for hire from The Open Polytechnic library. Students are provided with the Telecourse Study Guide which accompanies these videos and also relates to the textbook. The Learning Guide provided by The Open Polytechnic outlines the learning outcomes, discusses the organisation of the course, provides a study timetable and includes an assessment task booklet. A set of tutorial notes has also been produced - these give explanations of the more difficult topics and provide a series of worked examples and old examination questions. The software used is predominantly the student edition of *Minitab* (1999) or *Microsoft Excel*. The students are required to have one of these software packages on their home computers. Help in learning to use the software is provided by the *Minitab* manual or a set of notes for *Excel* included in the Learning Guide.

[1] Aged 20 years or over.

3.3 The sample

The total number of students enrolled was 128. Of these, two were excluded from the study because they were under 20 years of age and two others were excluded because they were living overseas.

The data was collected by two methods, questionnaires with open-ended questions which were sent at the beginning and at the end of the semester, and interviews. A detailed description of this data collection is given below in section 3.4.

All 124 qualifying students were sent the first questionnaire. These students appeared to be spread throughout New Zealand in a manner representative of the country's population distribution. A proportion of students did not complete the course over the semester (they transferred to the next semester or dropped-out completely). These students were not sent the second questionnaire, as the focus of this study was the opinions of, and strategies used by, completing students.

The students selected for interviews were chosen from among willing candidates in the following manner. All students who were sent the second questionnaire were asked if they were willing to participate in an interview (see Appendix 5). From among the 18 who responded positively, eight were chosen in a non-random but representative way. Tolich and Davidson (1999) noted that in qualitative research, samples are not usually drawn "according to probability theory (random selection) but upon essential and typical units" (p. 35). The eight students selected were chosen to represent both men and women, a variety of ages and a mix of experienced and inexperienced distance students. An information sheet and consent form (Appendices 7 and 8) were sent to the selected students. Once the consent form was signed, a suitable time for an interview was arranged.

3.4 Data collection

An initial questionnaire (Appendices 1 & 2) was mailed to the students described above just as the semester was beginning, and a final questionnaire (Appendices 3 & 4) was mailed just after completion and before examination results were known. Both questionnaire designs were finalised after preliminary questionnaires were pilot tested on volunteers from the previous semester. Questionnaires were chosen as a medium of data collection because they allowed access to a wide range of responses from a dispersed group of students. As all replies were anonymous, it allowed students to express whatever opinions they held without fear of identification. Burns (1996) noted that one of the advantages of a questionnaire is that the absence of an interviewer means that subtle bias caused by voice tone, probes, mood and expression can be eliminated. Furthermore, with less time pressures, the respondents have more time to give thoughtful answers and this seemed particularly important in this project as the majority of questions were open-ended, requiring reflection on the student's past experiences. Disadvantages of a questionnaire method include lack of flexibility, the inability to follow up on comments, the possibility of misinterpretation of questions and the possibility of a low response rate (Burns, 1996). These were considered when the methodology was first proposed, but it was felt that providing the opportunity for the majority of the students in the course to participate, far outweighed the disadvantages.

Additional data was collected by semi-structured interviews with eight students at the end of the course. Five of these were conducted face-to-face and three over the telephone. All interviews were taped and later transcribed. Marshall and Rossman (1999) noted that "a study focusing on individual lived experience typically relies on an *in-depth interview strategy*... the primary strategy is to capture the deep meaning of experience in their own words" (p. 61). This strategy was chosen to provide students' accounts of the process of learning statistics at a distance and their responses to, and interpretations of, the learning process. Burns (1996) noted that the advantages of interviews include increased flexibility, the ability to get more complete responses and increased motivation of the respondent due to rapport with

the interviewer; while disadvantages include the time taken to interview and analyse and the possibility of an interviewer effect.

The semi-structured interviews were conducted to expand the replies to the questionnaires. A semi-structured approach provided focus for the discussion, yet allowed the "richness and intensity of response" (Burns, 1996, p. 473) offered by open-ended questioning. In keeping with the semi-structured approach, the interviews were flexible and deviations from the possible lines of questioning (see Appendix 6) occurred. This flexibility has been described as fundamental to qualitative research and "permits a more valid response from the informant's perception of reality" (Burns, 1996, p. 330). The researcher was cognisant of the need to avoid directing the interview as "the participant's perspective of the phenomenon of interest should unfold as the participant views it, not as the researcher views it." (Marshall & Rossman, 1999, p. 108).

3.5 Validity and reliability

A common criticism of qualitative research is that it lacks the ability to demonstrate reliability (the extent to which research findings can be replicated). Tolich and Davidson (1999) argued that "from a qualitative perspective, reliability is not the goal" (p. 33), claiming that this type of research does not seek to generalise to the whole population but to provide a precise description of what people said or did in the research location. Merriam (1998) claimed that the term reliability in the traditional sense is inappropriate in qualitative research but that instead, evaluators of research should ask whether the results are consistent with the data collected and whether they are dependable. Dependability can be ensured by a clear statement of the researcher's position; triangulation and a clear audit trail (Merriam, 1998, p. 207). In this project, a clear statement of personal values, assumptions and possible biases is made, two data sources are used and processes are well documented.

In contrast to external validity, which is concerned with the extent to which the findings of one study can be applied to other situations, internal validity deals with the question of how research findings match reality (Merriam, 1998). To ensure

internal validity in this project two sources of data were used. External validity was enhanced by providing detailed descriptions, often referred to as "rich" data so that there is a solid basis for reader comparison with other situations. The validity could have been further enhanced by checking back with the interviewed students to make sure the interpretations agreed with the student's reality and by interviewing students from a different semester, or even a different course at another institution. These however, were beyond the scope of this project.

Triangulation, as discussed by Merriam (1998) above, is often claimed to improve the internal validity and reliability (or dependability) of qualitative research. Triangulation is the process of using "multiple data-collection methods, data sources, analysts, or theories to check case-study findings" (Gall, Gall & Borg, 1999, p. 305). It is useful to note that "triangulation in social science research sometimes does not produce convergence, but instead illustrates inconsistencies or contradictions among findings about the same phenomenon.... When this happens, it still may be possible to validate the conflicting data by reconciling them within an explanatory framework" (Gall, Gall & Borg, 1999, p. 305). Triangulation in this project was limited, in that only two data collection methods were used and the project was based on findings from students in one course and in one institution. However, as it was not intended to generalize the findings, but to provide insights into the learning process of Open Polytechnic students studying statistics, this appears adequate.

3.6 Ethics

The proposal for this research gained ethical approval from both the Human Ethics Committee, Massey University (PN Protocol 00/146) and the Ethics Committee, The Open Polytechnic of New Zealand.

The ethical standards that are common to all forms of research were adhered to: the participants were protected from harm, informed consent was obtained and the rights of participants were adequately protected. There are, however, some ethical issues which are more problematic in qualitative research than in other research methods. In a case study format, such as was used for this project, the anonymity of interview

participants is harder to protect. Although names are not used in the analysis, individuals may be recognisable due to the small number of participants and the type of detail about themselves which is revealed in interviews. Every care was taken in this project to ensure that no identifying information relating to participants was disclosed in the written results.

Other ethical issues which are often apparent in qualitative research such as the role of the researcher developing as an advocate, a friend or a reformer (Glesne & Peshkin, 1992) were not a problem for this project because of the short time frame and chosen methodology. Neither was there any element of exploitation or advantage to student or researcher, as no interviews took place until the course was complete.

3.7 Data analysis

"Data analysis is the process of bringing order, structure, and interpretation to the mass of collected data" (Marshall & Rossman, 1999, p. 150). In qualitative analysis, this is a complex process and often is intertwined with the data collection process. In this project, the objective of the analysis was to identify categories, themes and patterns and to present these in a way that brings meaning and understanding to the learning of statistics at a distance. The data analysis was undertaken by reading and rereading the questionnaires and transcripts and sifting for common themes and categories. Some patterns became apparent from the reading of the questionnaire responses, and this allowed interview questions to be modified to provide further illumination of these areas. Once all major themes were identified, the categories were given an alphabetic code and passages of the questionnaires and transcripts were marked with the appropriate code. At this point, useful quotations were also identified. As the analysis and writing progressed, it became apparent that some of the data could be coded in several different ways and that some of the categories overlapped. This is typical in qualitative analysis and, in this project, reinforced the overlap between students' personal lives, employment and learning. As well, there was conflicting data which emphasised the complexity of this type of data and forced reconsideration of some of the initial explanations.

Analysis and writing proceeded hand in hand until it was felt that all categories had been identified and the data fully explored. To present this in a way which captures the essence of the students' voices, it was decided to give an overall summary of the questionnaire responses and then to include interview findings and comments in a general discussion on the learning of statistics at a distance (Chapter 5).

3.8 The researcher's role

In qualitative research the role of the researcher as an instrument for the collection and analysis of data is undoubtedly influenced by existing perceptions and biases (Merriam, 1998). As a tutor at The Open Polytechnic of New Zealand for the last five years, I have observed the struggles of students trying to learn statistics at a distance and have built relationships with many of them (albeit by phone or email). I came to this project with assumptions about the difficulties of learning a visual and conceptually challenging subject in a distance learning environment and convinced of the importance of student support in such learning. Self-reflection has enabled me to be aware of these potential biases and to use them to gain deeper insights into the experiences of students. Although every effort was made to ensure objectivity throughout the data collection and analysis process, I acknowledge that prior experiences may have shaped the way I have viewed or interpreted the data.

3.9 Limitations

This project involved the students of one distance education statistics course at one institution. As other distance education institutions operate in different ways and offer different types and levels of support, the results may not be applicable to them. Furthermore, the purposive sampling for the interviews means that the results may not be applicable to distance education courses in general. However, it seems likely that similar findings would result from research done in other New Zealand institutions.

In addition, this study focused only on students who completed the course. A similar project using students who do not complete would be a useful addition to the research literature.

3.10 Summary

A qualitative approach was deemed the most appropriate method of obtaining data which would provide answers to the research questions. Literature on learning statistics and on learning at a distance both provide support for such an approach. The data was obtained by two methods – questionnaires and interviews, both of which allowed students to reflect on their experiences of learning statistics at a distance and express their opinions and feelings in a frank and open manner. The study was conducted in a clearly documented and ethical manner and analysed using a typical qualitative approach of identifying categories, patterns and themes and using these in conjunction with quotations from students to portray the experiences of students.

Chapter 4: Results

4.1 Summary of beginning questionnaire responses

The purpose of the beginning questionnaire was to find out how students felt about the statistics course they were about to start, their perceived confidence in successfully completing the course and the difficulties they foresaw.

This questionnaire was sent to 124 students in the first week of the semester. Forty-one female students and twenty-four male students returned the questionnaire within the two week period allowed for response. The overall response rate was 52%. A slightly higher proportion of women than men returned the questionnaire (55% for women and 49% for men). The results are summarised in this section according to the responses given to individual questions.

The vast majority of respondents were experienced distance education students, with only four students saying that this was their first distance education paper. At The Open Polytechnic, the programme co-ordinators generally advise students not to start with Statistical Analysis, as former students have reported difficulty with it and a high number of study hours are required. Many students are at least midway through their degree before they tackle it.

Several students said they had studied some statistics before, mostly at 6^{th} form level although there were a few who had studied statistics at tertiary level. Three respondents said they had failed this course before or had transferred from last semester.

Write down some words to describe how you feel about beginning this course.

Over one third of the women respondents used the word "apprehensive". The words "daunted", "overwhelmed" or "stressed" were also mentioned by both men and women. Some students were already saying the course was beyond their capabilities.

On the positive side, about one quarter of all students made positive comments, using words like excited, keen or looking forward to it. One student was "*keen to start, keen to finish*".

Can you explain what is causing you to feel this way?

By far the most common reason for feeling apprehensive or worried, was the mathematics background of the students. Many cited the number of years since they studied any mathematics. Typical comments were:

> *"I last studied mathematics nearly 30 years ago - we didn't even use calculators for stage one then!"*

Memories of mathematics from school years is obviously very focused on formulas and equations for many students. These were mentioned several times:

> *"Seems daunting, having to remember the mathematical equations."*

For other students, the concepts had not been encountered before:

> *"Can't decide if my calculator can do the work, let alone me! One glance at the work content shows it's all new."*

Also causing worry were the review questions in the Learning Guide (these are designed to give students an indication of the level of mathematics that will be required for the course) and the perceived volume of work.

On the positive side several students attempted to explain their determination to pass:

> *"Ignorance is not bliss! I don't just want to pass all of my courses, but I want to pass them well! It is important to me!"*

How confident of success are you?

This question provided a clear gender difference - the men felt more confident than the women. Almost all men were confident of successfully passing the course with such comments as "*failing is not an option*". The women on the other hand were much more tentative about their abilities with six students not at all confident of passing and others only feeling moderately confident. Some however, showed determination:

> *"I am determined to complete this course and have arranged my life around achieving this."*

Interestingly, four students expressed their confidence in terms of a probability or percentage (e.g. 80%).

Do you anticipate that this course in statistics will present any difficulties for you over and above those common to all distance education courses? Describe any additional problems you anticipate.

Women responded to this question more commonly than men. Some gave specific problems such as visitors staying or work deadlines. One was even worried about the road conditions at the examination time. Both men and women again mentioned mathematical weaknesses and the need to do extra work to fill the gaps. Many students seemed aware of the extra time they would need to put in to complete this course and several mentioned that the schedule appeared too tight. The use of software and calculators was only mentioned by three students. Communication with tutors was seen as a problem. Some students saw difficulty in finding time to communicate with tutors, while another commented that after hours availability of tutors was limited.

How do you think you might deal with these problems?

A variety of strategies were suggested, the most common of which was to set aside a certain time each week for study, *"Sunday is my school day - no compromise"*. A number of responses indicated that most students were taking responsibility for their own learning - they knew they had to be self-disciplined and many mentioned the need to set targets and make time for study by delegating or rescheduling other tasks. Women often mentioned help from family with babysitting but no men mentioned family support. Several students mentioned that they would be keeping in regular contact with their tutor and one suggested the tutors should be more proactive.

Many seemed to be taking a methodical approach to their study and mentioned working through the course material and doing the practice exercises:

> *"Hopefully I will stay focused, not become too despondent - seek help in all facets being offered to me and spend many late nights tearing my hair out."*

Only one mentioned the possibility of meeting with other students.

What concepts do you think you will be introduced to in this course?

There was a wide variety of responses to this question. Again, several students referred to formulas and equations:

> *"Application of formulas, when to use, how to use, presentation of."*

> *"The word 'statistics' conjures up all sorts of weird and wonderful things to do with mathematics; what the information gives people. I think that statistics is also a science where given mathematical information, we can work out what a predictable result will be."*

There were quite a few students who didn't answer this question, and some who said they didn't know what it meant. However, a substantial number seemed to have

some idea about what was involved:

> *"How to organise data collection to give the information required. How to read data in relation to background knowledge. How to form opinions and decide on plan of attack."*

Among the specific statistical topics that are included in the course, the most commonly mentioned were probability, normal curves, histograms, means and standard deviations. At the most basic level some students optimistically replied *"Statistics"* while one said *"Everything greater than multiplication, division, addition and subtraction"*.

What do you think is the value of having a compulsory statistics course in your degree?

Most students saw value in the course as a compulsory paper in their degree. Only two students said that it was of no value to them and should be an optional paper. Five others were unsure of the value and were waiting to see what the course covered. Many mentioned the need to be able to interpret data in managerial positions, summed up by one student:

> *"Everybody, in whatever job they do, will come across having to put together information and decipher the meaning of it, make decisions based on it or present it for others."*

Others had a more light-hearted approach, with one student noting:

> *"Helps to understand why certain shoe sizes are hard to get."*

4.2 Summary of final questionnaire responses

The purpose of the final questionnaire was to determine how the students who had completed the course now felt about learning statistics, to record any problems they encountered (both anticipated and not anticipated) and how they dealt with them, and to record the students' ideas for improved support mechanisms.

This questionnaire was sent out after the examination, but before final results were known. Students who had transferred to the next semester or who had not completed the course were not sent this questionnaire. Of the remaining 68 students, 42 returned questionnaires, giving a response rate of 62% and again more female responses were received than male ones. Again, the results are summarised by looking at the responses to each question individually.

Now that you have completed the course, write down some words to describe how you feel about learning statistics?

Most responses were positive and used words like "achievement" and "interesting" were commonly used. A typical comment was from this female student:

> *"I actually enjoyed the course and it made me interested in statistics - just wish I had time to do it justice."*

Several students, although giving a positive response, qualified it with a comment to the effect that they had found it difficult or that it had been very time consuming.

Only two students gave a totally negative comment:

> *"Oh no! Not statistics! Pessimistic about the outcome of results."*

> *"Don't wish to encounter this subject ever again. Relieved it is over."*

Can you explain why you feel this way?

This question provided some interesting responses. Comments fell into three broad categories.

Mathematics

This was mentioned several times in this question, for example:

> *"It is a very maths oriented subject - I found it difficult."*

> *"I'd not had a lot of experience of stats and my maths wasn't strong so the course seemed difficult prior to even starting."*

Support mechanisms and learning resources:

The most common comment here related to the help received from tutors, but the textbook and videos were also mentioned by several students:

> *"It appeared complicated at first view but the method and the tutors helped make it enjoyable and fun."*

> *"The videos helped to put a use to what was being learned - added practicality."*

Statistics as a subject:

Several students again mentioned the feeling of accomplishment and relevance to their own situation:

> *"I feel that the course has given me a greater understanding of the technical aspects of analysing data. I have the tools to apply to my psychological study."*

"Statistics was quite alien to me when I began and some of the concepts very hard to grasp. Now I feel as though I have really achieved something that I was anxious about and I am proud of that achievement."

Did you encounter any problems in the course over and above the usual problems of trying to juggle work and family responsibilities with your study?

The problems raised can be grouped into four categories.

Mathematics

As before, the mathematical component attracted comment:

"I needed to revise maths as I hadn't done any for many years, I found it a bigger workload than other courses."

Support mechanisms

There were several positive comments about help from tutors although there was one negative one:

"I didn't find the tutors particularly helpful when I had problems I needed further help with. After phoning and emailing for a couple of things, I didn't come away feeling any better or more confident."

This was in contrast to:

"The project was very daunting as I had never done anything like that before. But once again the support from my tutor was great and the apprehension was eased."

Some comments touched on the lack of immediacy of answers to problems:

"The need for immediate feedback and explaining the difficulties over the phone or email."

Resources

These comments centred round the materials provided by the polytechnic or purchased by the student. Most related to the textbook or the software:

"Having to learn a whole new computer system at the same time."

"The textbook was a tad on the expensive side (good quality book though). Would like to have viewed the videos to gain a better understanding but the fee was too much for me to afford."

Concepts

Several students commented that they had found it a difficult subject to learn, and mentioned new and challenging concepts:

"The concepts were hard to grasp. For a complete stranger to stats it took me a lot more time than any other course to date and really challenged my ability to learn something new."

What sorts of things helped your learning?

By far the most common comment related to tutor assistance, but resources such as the videos, the textbook, the tutorial and the tutorial notes also received several comments. Several students noted that by reading and rereading the materials, working through examples and/or completing the assessments, the topics began to make more sense to them.

Tutors

"Knowing that the tutors were very supportive and replied quickly to distress calls."

"Definitely the availability, kindness and knowledge of the tutors."

Resources

"The videos to show how principles could be applied."

"Having the Study Guide to work through and a timetable to keep me moving on."

"The tutorial and knowing I wasn't the only person struggling."

"Tutorial notes were great."

"It was good to read in the internet forum that other people were struggling too."

Own initiatives

"Reading and rereading the notes."

"Repeating numerous exercises."

"Doing the assessments."

What sorts of things made it difficult?

This question had a variety of responses, again comments on mathematics outnumbering any others. Comments relating to resources mainly focused on the

textbook, while several others commented on the difficulty of understanding the concepts and the lack of time available. Several other students commented on having to use Eton tables in the examination even though these differed from the textbook tables.

Mathematics

> *"No maths skills or experience - dropped maths in 4th form - had no idea about algebra."*

Textbook

> *"A text that assumed a lot of prior knowledge I didn't have. Textbook only gave answers to odd-numbered questions."*

> *"For me the textbook was verbose. The repetition with only slight variation was frustrating."*

Concepts

> *"Lack of clarity. Differences were not explained. There were also situations where only part of the equation/reason was explained - leaving you to have to ask."*

> *"Difficult subject to learn by distance learning."*

Time

> *"There was a lot to cover in a short time. Perhaps more time left for exam study would have helped. I felt like I worked constantly right up until exam week."*

What additional types of support might have helped?

Several students replied that they were happy with the support offered. Typical comments were:

"I had great support from TOPNZ and family."

"The support options open to me were more than adequate."

"I think the support is there, but I should have used them more."

Contact with other students

Several students mentioned they would have liked contact with other students, both for social support and for sharing of knowledge:

"Contact with other students on the same course."

"Study groups to bounce ideas off."

Tutorial contact

The demand for more face-to-face contact between tutors and students was frequently noted:

"A tutorial in Christchurch."

"An additional optional weekend tutorial."

"For this course I think I needed face-to-face communication."

More explanations/worked examples

It was apparent the resources didn't provide enough explanation for many students:

> *"More involved answers to the exercises explaining exactly how the answer was arrived at."*

> *"Information sheet on how to do equations and why they were done like that."*

Looking back on the course, what do you think are the most important ideas you will take away from this course? Can you explain why you gave these ideas?

Most comments stressed the diversity of statistics, their applications in a variety of situations and the caution needed when using or interpreting them:

> *"Statistical methods and formulae can be used in a variety of situations."*

> *"That some statistics have to be taken with a grain of salt and that not all experiments are valid."*

> *"That statistics is very interesting and can be used across many subjects. I like Chi-squared tests!"*

> *"There are definite methods available to prove and test theories in real life everyday situations. An awareness of how publications mislead readers by inappropriately displaying data and lack of validity."*

> *"Basically that there are some fantastic tools for analysing and assessing data but that you have to be prudent when using them."*

> *"The often tenuous nature of data and interpreting results whenever I hear/see the results of surveys and questionnaires published or on TV."*

One respondent commented that he had learned *"Not to do statistics again, or to do it over a full year."*

When asked to explain why they gave the above ideas, most commented that they now have more insight to how statistics are arrived at and that they have learnt to be critical of data collection methods. Some also mentioned the videos gave them insights into use of statistics in various real-life situations.

How confident with using statistics do you now feel?

Most students felt reasonably confident, especially with using graphs and descriptive statistics. Most seemed aware that they had just touched on the subject and many realised their textbook could be used as an on-going resource. Typical comments were:

> *"Comfortable, although there is clearly more to be learned."*
>
> *"Moderately - I feel I need to have the books close by to ensure that I don't go off track."*
>
> *"Very confident with basic stats, less confident with formal inference."*

Do you think you will use any of the things you have learned in the course? Please give examples.

The majority of the students did think they would use techniques and ideas taught in the course. Several students mentioned they were majoring in psychology and would need statistics for research. Other students also mentioned its use in other papers they were studying. In the workplace, most students saw uses in a variety of occupations:

> *"I can see using them at work for reporting library collections and other things."*

"The fire brigade is presenting some statistics to the local paper to publish and they have asked me if I'll do the analysis and graphs."

"Monitoring wildlife and environmental systems with DOC."

"Work analysing quality data and completing surveys."

"Trends involved in our business."

"Not necessarily but at least I now have an understanding when statistics are bandied around, especially in the media."

The final set of questions asked how effective they found the various learning resources provided in this course.

Textbook

The textbook received a 'thumbs up' from about half the students. Most of those remaining gave qualified support, while a few were critical of it. Typical comments included:

"Surprisingly straightforward to read - very effective."

"Good but some extra explanations/examples would have been good."

"Not very user-friendly - quite heavy going."

"I found the textbook a hard read - it's not exactly a Bryce Courtney is it?"

The most common criticism was that it only gave answers to odd-numbered questions, a feature that several students commented on.

The Study Guide (an accompanying book to the videos, which also provides an overview of each of the book chapters, fully worked examples and self-test questions with answers).

This received overwhelmingly positive comments with only four students saying that it did not provide sufficient explanations. Comments included:

> *"Very effective. Showed practical applications, explained difficult principles in ordinary language."*

> *"Good, especially the self-test questions. Having the answers and explanations was great."*

The videos (The *Against All Odds* videos are an optional extra resource and are available for hire from the library).

All students who had used these found them to be excellent:

> *"Extremely effective, interesting topics, appropriate language and presentation. It helped round out my understanding."*

The CD-ROM and Media Activities Book (These came with the purchase of the 3rd edition of the textbook - not all students purchased this edition).

The CD-ROM seems to have had little use. Of those who tried it, the comments were mostly negative:

> *"Only had a quick look, didn't think it of much use."*

> *"I had a look at it, but it didn't seem relevant or helpful."*

The Media Activities book attracted similar comments:

"It was not easy to use."

The tutorial notes (these were a set of notes prepared for use at the tutorial and made available to all students. They included worked examples of past exam questions.)

These also got overwhelmingly positive comments:

"Very helpful, in fact probably the most helpful."

"I used them in the last 2 days before the exam - very helpful."

"Very good, used plain language to explain things."

The few negative comments suggested they needed more worked examples and more explanation of "why" things were so.

The on-line campus forum

This appeared to have had a positive impact on reducing the isolation of the students and was used for social support rather than as a learning resource:

"The main thing is that it made me feel less isolated."

"Very good to know how other students were coping"

"The comments and responses from tutors were very very helpful."

4.3 The interviews

Interviews were conducted with eight students in the two weeks following the return of final questionnaires. These provided the opportunity to probe the responses given and were especially valuable for following up affective and attitudinal responses. The results of the interviews have been incorporated into the discussion in Chapter 5.

Chapter 5: Discussion

Initially the discussion will centre round the research questions outlined in Chapter 1. Then broader issues, highlighted in the literature review (Chapter 2) will be discussed.

5.1 Discussion relating to the research questions

Discussion relating to the specific research questions relating to this project will be based on the responses to both questionnaires, summarised in Chapter 4, with added detail obtained from the interviews.

5.1.1 Research question 1. How do students describe the way they are feeling about beginning a distance-education statistics course?

There was evidence that most students were quite apprehensive about beginning this course. Apprehension is not unexpected at the beginning of a new course, and possibly this word would be used by many students, whatever paper they were studying. One interviewed student commented that her apprehension was partly caused by hearing other students talk about various statistics courses:

> *"I felt fairly apprehensive coming into the course as I had seen my flatmates do stats papers - coming home and working through assessments."*

Another noted that even comments from the general public portray statistics in a negative light:

> *"I read a lot on the train and people sitting beside me would say "Oooo stats!"*

However for most students the apprehension seemed to be due to the mystique that mathematics and related topics have in society in general. Mathematics has always

been an elitist subject in schools and it is currently acceptable, even commendable, for otherwise accomplished adults to admit that they have never been good at mathematics. The poor mathematics backgrounds of students attempting a first year statistics paper has long been a concern for many statistics educators. For those offering a paper by distance education the problem is accentuated. Firstly, the majority of students learning this way are older and therefore, it is often many years since the students have done any mathematics. Secondly, and also because of their age, many learnt mathematics at a time when memorisation of formulae and rigour of proof were the norm in teaching mathematics. For many of these students, memories of their mathematical classes were not favourable. Thirdly, an open-entry policy for students at The Open Polytechnic of New Zealand means that a significant number of students have limited secondary education.

Although a recommendation for 6th form mathematics applies to the course under consideration, it is obvious to those teaching this course that many students attempt it without this level of mathematics. While believing that students must take some responsibility for getting themselves adequately prepared for this course, The Open Polytechnic is also accepting some responsibility and will be offering a bridging course in mathematics next year. This will be targeted at those who have not done mathematics for many years, or who left school with less than 6th form mathematics. However, there will not be any enforcement of qualifications and it is expected that some students will attempt to shortcut the process and continue to enrol in statistics without a sufficient level of prior mathematical knowledge.

The results did also show, however, that even students with quite adequate levels of mathematics, were concerned about this aspect at the beginning of the course. Some students who had not done mathematics for some time reported some retrieval of 'forgotten' mathematics:

> *"The maths wasn't as bad as I expected. It is surprising how much you can drag out of the old cobwebs."*

> *"When I first got the book and looked at the revision stuff, I thought I had*

forgotten what some of these words like factorise meant, but once I sat down and applied my mind, I did realise that I could pull some of that stuff out of my memory."

Several students who had not done mathematics for some time did take responsibility for updating their knowledge and mentioned that they had obtained library books to help 'brush up' their mathematics.

It is of concern that some beginning students felt overwhelmed and negative about the course before they began. There is no way of knowing from this project whether these students completed or not, as the beginning and final questionnaires were not matched up, but it seems likely that they did not complete. As with all distance education courses, there is a certain percentage of students who fail to complete. Previous research has shown that the drop out of distance education students is due to a variety of reasons: outside influences such as lack of time, family crises etc.; student attributes such as motivation, perseverance, academic ability; and factors that relate to the institution (Grote, 2000). There were some students in the course however, who had an impressive academic record but who seemed unable to cope with a statistics course despite continued efforts by the tutors to provide help and support. Possibly these students need a special programme such as that described by Patrick (1999) for adults lacking confidence in mathematics. Patrick noted that increased confidence and recognition of existing skills and knowledge resulted from increased critical consciousness and use of critical reflection. Tobias (1993) has also noted that mathematical anxiety can prevent intelligent adults learning mathematics and this definitely was apparent in many of the beginning students' responses:

"fear of maths and my ability to understand."

There was undoubtedly some anxiety shown by students, not only due to mathematics but also because of the novelty of the concepts. Gal and Ginsberg (1994) noted that statistical anxiety may affect the interest, motivation or comprehension of students, so it is important that these issues are acknowledged. Also, Roiter and Petocz (1996) argued that "the affective domain of learning is sometimes left to chance, but

recognising and addressing concerns about anxiety seems to be a vital initial step in the design of introductory statistics courses" (p. 1). However, as discussed in the literature review, there is not necessarily a lot that educators can do about changing these feelings. The options for distance educators to discuss anxiety with students include use of newsletter, electronic forum or personal phone calls. All of these methods however, lack the personal rapport which could develop in a small face-to-face class. There is also no clearly established method of determining which students are anxious and which are not. A brief introductory phone call can be used to discuss anxiety with the student, but this is not necessarily an accurate way to determine the extent of the anxiety and may do little to alleviate the problem.

Overall, however, the findings relating to the confidence of the students contradicted those of Townsend et al. (1998) who reported 64% of second year educational psychology students surveyed at the University of Auckland said they did not feel confident at the beginning of their course. In this study, the proportion was much lower with only about 15% saying they were not confident or only moderately confident. Among the students interviewed, and also apparent from the questionnaire results, was a clear determination of many of the students to succeed. Some students rearranged parts of their lives:

"I gave up my job and had four-week slog before the exam."

Is there evidence then that "the common denominator of students beginning their study of statistics is dread" (Diekhoff, 1996, p. xv)? In responses from students at The Open Polytechnic, there were enough positive comments to suggest that this is not the case. Certainly there was apprehension and anxiety but this seemed mainly to be due to doubt about mathematical skills. If this could be addressed, there is reason to believe that most students would enter their statistics course with enthusiasm and optimism. Most of the comments referring to hated statistics courses emanate from the United States and there is little evidence to support these claims from this group of students. It could be that because New Zealand has a relatively long history of teaching statistics in our schools, students see the subject in a more positive light than their American counterparts.

5.1.2 Research question 2a: What value do students see in a compulsory statistics course?

All interviewed students were positive about the value of having a compulsory statistics course in their degrees:

> *"There is so much of what you do in management these days that involves analysis of information, so you need a strong set of analytical skills."*

> *"I can't think of a degree where you would want to walk away having finished it and know nothing about statistics. I think it has real value as it can make sense of a lot of real life situations and aid understanding of those situations."*

This reinforces the findings from both the beginning questionnaires and the final questionnaires where the majority of students saw the importance of doing statistics as part of their degree. There didn't seem to be a need to convince students of the importance during the course as most already were aware the importance of being able to read and interpret data before the course began.

Nevertheless, most of the interviewed students said they would have been unlikely to choose the paper had it been optional:

> *"I wouldn't have chosen it as my preference is for more people oriented stuff."*

This is in keeping with Gordon's (1995) findings that 73% of her psychology students would not have chosen to do a statistics paper. This presents a paradox - a subject that is seen as important to a degree but not one that students want to do.

5.1.3 Research question 2b: How do students perceive the paper before and after completion?

Before the course started many students seemed to have little idea of what was involved. This is despite the fact that, except for the oldest students or those educated overseas, they would have encountered at least basic statistics in the school curriculum. It may be that because statistics is taught as part of the mathematics curriculum in schools, students have difficulty in disassociating it from mathematics. The implications for this are that any negativity associated with a statistics paper may be due to either hearsay or on the mistaken idea that it is based on formulae and rigid mathematics. It is understandable that students don't know in detail what a new paper will entail but it appears that statisticians have a role in informing the general public about their subject so that at least people will have some idea about what the subject is all about.

Gal and Ginsberg (1994) have also noted the "fuzziness" of the term "statistics" for many beginning students and use this as further evidence of the limited usefulness of attitude scales which use the word "statistics" in many of their questions. They also noted that "other than the commonly held belief that statistics is heavily mathematical, students' beliefs about statistics remain unexplored" (p. 12). McLeod's (1992) summary of the research on beliefs in mathematics education called for "stronger connections between research on beliefs and research on emotions" (p. 581) and this could apply to statistics education research as well.

Following the course, the completing students no longer mentioned mathematics when asked about what the main ideas in the course were. Instead, they concentrated on the tools they had obtained and the understandings they had gained. Most agreed that the course would be of value to them, in their future study and in their workplaces:

> *"The main ideas I took away were to do with research. This fitted in well with my psychology papers - hypothesis testing, experimental design, sampling, the basic principles of good research design."*

"I learnt how hard it is to take a good sample and how much influence this can have on the final result."

"For understanding things in the news and media. So many figures are thrown at us. Most people have no idea what it is all about. It opened my eyes to a lot of things."

"It has opened up a whole new world, that I think I knew was there all the time, but now I can actually see the meaning in it, see the rationale behind it."

So students appeared to perceive the course as being directly applicable, not only to their personal lives, but to their understanding of the way data is used in everyday life. Several also mentioned the need for more study:

"I'm still a beginner but I have more faith in statistics now that I understand inference a little."

"I'm intrigued at how statistics applies to anything and interested to know more."

The idea that a statistics course should not block the demand for further instruction was explored by Gal and Ginsberg (1994), who argued that "statistics teachers should aim to engender in students a positive view of statistics and an appreciation for the potential uses of statistics" (p. 3). It appears as if this aim has been met, for at least some of students completing this course.

5.1.4 Research question 3: What problems unique to learning statistics by distance education do students perceive? Were these problems successfully dealt with by completing students and if so how?

There were surprisingly few problems anticipated by beginning students. Lack of time was seen as a factor, not surprisingly as most students were working full-time, and again, mathematics ability was frequently mentioned. Following the course, the

difficulty of statistical concepts was frequently mentioned, along with mathematics, support mechanisms and resources. Discussion will centre round these four categories.

Mathematics

Some students felt that problems associated with a weaker mathematics background were less able to be addressed in a distance environment. In a face-to-face situation, the teacher can stop at any point and explain a mathematical process. In a distance environment, however, the student is reliant on the learning materials to explain each step. As most statistics text books are written assuming a certain proficiency in basic mathematical skills and calculator use, they rarely explain steps from a basic level. It may be that distance educators assume too much mathematical knowledge. Past experience suggests that many students have difficulty with basic rearrangement of equations, substitution into formulae and calculator use such as finding powers of numbers. It is up to the students to ask if they cannot do the basic mathematics and many of them simply do not. Whether this is due to laziness, embarrassment or some other factor is not clear. Consequently, students learning at a distance are at a disadvantage if they lack basic mathematical skills.

The 'symbol shock' referred to by Tanur (1997) as discussed earlier was most apparent, with algebra presenting the most problems to students:

> *"No maths skills or experience - dropped mathematics in the 4th form - had no idea about algebra."*

Some students dealt with this by obtaining extra mathematical resources as discussed above. Not surprisingly, many who had to revise their mathematics before they started, found that the time to complete the course was too short. Others failed to address their weak mathematics background and had difficulties in the assessments and examination.

Support mechanisms.

The support received from tutors generally met with a very favourable reaction:

> *"My first contact with my tutor was very helpful. At first I was reluctant to ring as it was only a little problem but he was wonderful and gave me good information and encouraged me to ring again."*

Although there was widespread support for the free phoneline and email access to tutors, the immediacy of getting an answer again presented problems for some students. Many studied during the evening and were too busy at work during the day to ring their tutor:

> *"The main difficulty was that I was doing my study in the evening and I didn't think I should be ringing my tutor at 10pm."*

Distance students may be mistaken in thinking that face-to-face students have more opportunity for asking questions. In large first year courses, the opportunity for individual attention is probably less than is offered to distance students. Certainly in tutorial sessions there may be further opportunities to get worrying aspects attended to but face-to-face students still study in the evening when tutor help is unavailable.

There is anecdotal evidence that distance students are becoming more demanding in their quest for immediate answers. With the increased use of email, some students expect that their tutor will be available, and have the time, to answer immediately. Certainly, immediacy of answers was one of the things frequently mentioned by the interviewed students:

> *"I would have preferred to do this course face-to-face because of the ability to ask questions and the immediacy of answers."*

> *"If I had done it face-to-face, I don't think I would have needed to spend so much time, as I would have had someone to explain the answers."*

Some students supplemented their tutor support by accessing other people in their communities, some with more success than others:

> *"I found other people who had done statistics who I could ask"*

> *"I ear-bashed my husband but he wasn't much use."*

> *"I'm lucky in that I've got some business analysts here, so if I got stuck with concepts I could go to someone and say 'hey look, I don't understand - what's the story here?'"*

Resources

The resources for this course consisted of a textbook, a study guide, an optional set of videos, an electronic forum, *Excel* or *Minitab* software, a set of tutorial notes, a media activities book and a CD-ROM. The students' evaluations of these resources were discussed in Chapter 4 and it seems important to take account of students' perceptions of their design and usefulness, as "it cannot be taken for granted that students perceive the learning situation as the educator does" (Gordon, 1993, p. 45).

One interviewed student found it difficult to establish how to use her materials, suggesting that there is room for improvement in the layout of materials:

> *"At first I had some admin problems -trying to sort out what I was meant to be doing - whether I worked straight from the textbook or what."*

Some students, especially one who had done recent study at a traditional university, found working directly from a textbook presented a few difficulties:

> *"Distance education is quite different from learning face-to-face. It is easier if there is someone to work through the examples step by step."*

The difficulty of explaining a process from a distance was also raised:

"It is easier if there is someone to work through the examples step by step. Although you have the finished example in front of you, it is different from having someone do each step - adding to it each time."

For a subject which is aided by diagrams and sketches to such a large extent, tutors are well aware of the limitations of teaching from a distance. However, this too can be overcome with new technologies, as some on-line courses have a whiteboard attached, so individual instruction can be given, complete with diagrams. The Open Polytechnic is hoping to use this technology in the near future.

As well as learning directly from the textbook, students learning at a distance have to teach themselves to use the software. In comparison with face-to-face students who can have a lesson in a computer laboratory, distance students are required to work through the tutorials provided in the *Minitab* manual, or, for those using *Excel*, a set of notes sent out as part of the learning materials. This however, may also be a positive feature, as having the software on their own computer, while having financial implications, also means they can get easier access and more exposure to it than would be obtained in computer laboratories. The students seemed to integrate their software learning with their statistics learning:

"I used Excel software. I didn't know much about it when I started but I worked through the exercises in the appendix and it worked well. It went hand in hand with my learning."

"By doing some of the Minitab tutorials, it helped gel some of the ideas about what you are trying to do and I found it pretty easy software to come to grips with. This was an additional burden in terms of cost, but not time, as working through the examples helped cement the concepts."

Although none of the interviewed students had trouble using the software, one commented:

"I would feel for someone who had never used software before - you would

just about need to do an Excel course before you start."

Two of the interviewed students made good use of internet links provided by the tutors or found their own links by searching the internet:

"I'd check out some of the ideas on the websites."

"I looked on the internet for packages for a free trial."

Concepts

Without someone immediately at hand to explain the concepts, distance education students need to rely more on their own determination and metacognitive skills. There was evidence from this group of students that they did find a range of concepts difficult and this seemed to take students who had previously been successful in their distance education studies by surprise:

"When I started looking at 'from probability to inference' - what does that mean? By that stage I had got myself into a situation where I thought I needed to know all the detail and I was struggling to stand back and understand the implication of it all. I read the words off the page without really being able to understand it in a New Zealand context. I started to make life difficult for myself."

"I think that the concepts are harder to come to grips with than other subjects I have done."

"Courses I had done previously were close to the nature of my job, so they were things I was familiar with whereas statistics wasn't."

The conceptual difficulties were overcome by a variety of means – support mechanisms and resources as described above and cognitive engagement with the ideas.

The notation used in statistics can also be perceived as a problem for distance students and some developed their own ways of coping with this:

> *"I don't know the Greek alphabet so I would have a picture in my head of the symbol, not the word. I tried to make a mental note that that particular symbol related to the population mean or whatever, so that when I saw the symbol, I immediately thought population mean. The word didn't matter as long as I knew what I was referring to."*

Students who had used the videos or attended the tutorial day had less problems with symbols and notation. Godden (1998) found this to be a benefit of using video-taped lectures for nursing students, "hearing the names of symbols enunciated, and having the solution to a problem demonstrated, were the most valued more tangible features" (p. 1276).

5.1.5 Research question 4: What additional support mechanisms do students perceive as useful?

As discussed earlier, most students were impressed with the amount of support offered to them by The Open Polytechnic, and several noted that they hadn't made full use of the support available, mainly due to time constraints:

> *"My own fault for having huge family and work commitments."*

Among the suggested improvements, more face-to-face contact was the commonest theme. The only face-to-face contact available to this group of students was a one-day optional tutorial held in Auckland and Wellington. All interviewed students who had attended the tutorial had found it useful, both from a cognitive and from a social point of view:

> *"I think the tutorial put things in logical perspective - about how things linked together and got rid of some of the anxiety."*

"I was relieved to find out that there were other people who found it as hard - I thought I was the only one really struggling with it. So I didn't feel I was really dumb."

Some however, found it too rushed and suggested two days. There was also demand for a Christchurch tutorial. Conference calls and an on-line chat room were also suggested.

Other suggestions for improved support mainly related to resources: clearer textbook, better Learning Guide and more worked examples.

5.1.6 Summary

The group of distance education students involved in this project appear to be mainly well-motivated, independent learners who made good use of available resources. While many were apprehensive when beginning the course, this seemed to be mainly due to a real or perceived weak mathematics background. Most students saw value in doing a compulsory statistics paper and completed the course feeling a sense of accomplishment. Determination to succeed was a feature of the group, with sacrifices made in both work and home life to achieve this. The problems due to studying at a distance were mainly related to explanation of the steps of a problem, either mathematical or statistical. The lack of immediate answers to questions was also perceived as a problem. To overcome these problems the students looked beyond the provided resources and made use of other books, people in their community or the internet. There were however, a group of students who began the course with negative attitudes and a lack of confidence. The challenge is to identify such students at the start of a semester so additional resources can be provided. In a distance environment, this is a challenge indeed.

5.2 Statistics education reform - implications for distance learning

As discussed in chapter 2 (section 2.1.3) there have been changes in the way statistics is taught over the last decade. Proponents of these changes called for more emphasis on statistical thinking, more use of real data, less emphasis on probability theory and formal derivations and encouragement of active learning by means of group activities, oral and written presentations and projects (Moore, 1997). While there is still debate over the learning outcomes, course content and style of assessment which would best suit students who are only likely to ever do one statistics course, there is little debate over the overall objective of such courses: "A major concern of those who teach statistics is how to ensure that the students understand statistical ideas and are able to apply what they learn to real-world situations" (Garfield, 1995, p. 25).

The course discussed in this project follows a relatively modern format, with less emphasis on probability theory and more emphasis on data production and data exploration. The direction of the course is determined by the order of topics in the textbook and it was clear that most of the interviewed students followed the suggested timetable quite closely. In distance education, the textbook and other learning materials provided are of primary importance for successful learning and the perceived effectiveness of the textbook will be further discussed in section 5.4.

The integral use of software in the course is intended to help students learn basic concepts. However, it appears that given the time constraints, most students used it solely as a substitute for manual calculations and to meet the assessment requirements. The limited use made of the CD-ROM accompanying the textbook and the Media Activities book showed that few students were able to take full advantage of the possibilities it offered. It is not known whether this was due to the design of these resources or possibly because their use deviated from the structured approach of the course shown to be preferred by many students doing a first course in statistics (McAlevey & Stent, 1999, Tanur, 1997). Ideally, software should be used to enable students to explore the data more fully by displaying it in different ways, simulating and analysing data under different assumptions. Attention needs to be focused on how distance educators can encourage students to participate in this way.

Even with the use of the computer to do the calculations, many students completing the course still saw the subject as containing a lot of mathematics:

> *"It is a very maths oriented subject - I found it hard."*

> *"All the formulas!"*

It is apparent then, that some students, probably those with the weakest backgrounds in mathematics, never get beyond worrying about the calculations. This barrier is preventing them getting an overview of what statistics is all about. It is possible that, by allowing students to enter the course without any formal mathematics education, a disservice is being done to both students and teachers.

It is clear to statistics educators that statistics has its own set of concepts, quite unrelated to those in pure mathematics and often quite foreign to students. Clayson (1998) commented, "we forget, I think, just how weird statistics is to most undergraduates, certainly to the non-science ones" (p. 1077). Teachers must find innovative ways of presenting the concepts, while recognising the difficulty many students have in grasping them.

One such way was advocated by Garfield (1995) who suggested having students confront their own misconceptions about statistical ideas, especially about chance events. She also noted that teachers often overestimate how well their students understand basic concepts, a point commented on by a student completing this course:

> *"Tutors rushed through the steps thinking it was easy for everyone to understand."*

Predominant among the general principles of learning statistics which Garfield (1995) lists, is the active involvement of students in learning activities. Garfield argues that research shows that students learn better if they work co-operatively in small groups, which provide opportunities for students to express their ideas both orally and in writing. In distance education, this is difficult. Even with new technologies, the use

of small groups of distance education students working together is likely to be far less successful than in a face-to-face environment. Also, the opportunity for this type of interaction within a first year statistics course may be limited by students' experience and skill base. Carr-Chellman, Dyer and Breman (2000) found that:

> It is possible to enact authentic learning and distance collaboration within modified distance education when learners are advanced in their studies, have had previous experiences collaborating at a distance with smaller projects, and are prepared for the challenge of authentic experiences by seeing strong relevance to their own work. (p. 39)

Commenting on the above piece of research, Henri and Haughey (2000) claimed that "collaboration is one of the most challenging human activities. It banks on abilities that are not innate; it has to be learned" (p. ii).

It was apparent that even using the on-line forum was daunting for some students so it may be that expecting first year students who don't know each other to co-operate on a project would be short-sighted. One student noted:

> *"I read others' messages but did not join in. I believe it could be used far more for discussion but still seem reluctant to join in."*

Nevertheless, active learning by engagement of distance education students with their study is still possible. Hands-on activities, computer simulations etc. are possible for distance students and activity based courses are available. Consideration could be given to incorporating more of these into the course design, especially as part of the assessment process.

In conjunction with the changes to the course content and style of delivery of statistics courses, has come a call for changes in the assessment process. Since there will always be some students who will only do what is required to pass the course, Hubbard (1997) noted that assessment "can be used as a powerful tool to encourage

students to adopt deeper rather than surface learning strategies" (p. 1). The assessment for the course studied in this project consists of two assessment tests, an examination and a project, for which students collect data themselves and choose appropriate analysis. The assessments seem to have been well received:

> *"The assessments were really good for firstly making sure you understand the work and secondly, making it applicable and thirdly, seeing its relevance."*

The project, while encouraging students to use data they were interested in, met with a mixed response:

> *"The project was wonderful - it took me a while to decide what to do, but once I was away, it was excellent. I really enjoyed it."*

> *"I felt we didn't have enough statistics information to manipulate the data in order to do the work."*

> *"Doing the project helped, especially relating to chi-square tests."*

Hogg (1991) noted:

> Projects give students experience in asking questions, defining problems, formulating hypotheses and operational definitions, designing experiments or surveys, collecting data and dealing with measurement error, summarising data, analysing data, communicating findings, and planning "follow-up" experiments suggested by the findings. (p. 342)

While not all these aspects are expected for the course under discussion, the project still gives students a chance to experience the difficulties in gathering data and the opportunity to practice their statistical communication skills. While an oral, or video-taped, presentation is permissible, no students have taken up this option. Within distance education, the skills for oral presentation are more difficult to encourage and

assess.

It is possible that the project could be better managed by allowing the assessment to be done in several phases, with feedback after each. A longer time period would be needed to accomplish this, so consideration could be given to eliminating the examination. The idea of an examination as a fair means of assessment for adult students is subject to debate:

> Formal examinations mean that mature students are given only the same time as those aged 18-22 years in which to recall the salient points on a topic, as well as to use them in a constructive logical way in a response. There would seem to be a great deal of evidence, even if retrospective, that such exams are not a suitable or fair means of measuring the performance of mature adults. (Sutherland, 1997, p. 199)

Students are required to get at least 40% in each assessment so sometimes the examination makes the difference between a pass and a fail. One student commented on this:

> *"An exam, based on memory skills, should not be the sole decider on whether or not that course is passed."*

Even in its current format, the time over which the course is run needs further consideration. Several students mentioned lack of time to understand concepts and reflect on their learning:

> *"You vaguely learnt something then had to move on to something else. I didn't feel all that confident through much of the course that I had absorbed it as well as I should have and that was because it was so rushed."*

> *"New concepts took a long time to understand and fit into the scheme of things. Why, where and when are those concepts used?"*

"We were motoring through the textbook at breakneck speed - no time for contemplation."

Parker, Pettijohn and Keillor (1999) also noted this: "A limited resource in the introductory statistics course is almost always time; there are too many critical subjects to discuss and too little time" (p. 4).

For distance education students, most of whom are working and raising families, the time frame over which a statistics course is offered needs serious consideration. If we expect our students to meet the objective noted at the start of this chapter, then an appropriate time-frame must be negotiated.

In summary, while The Open Polytechnic course Statistical Analysis has gone some way to addressing the issues called for by statistics educators, more can be achieved by encouraging more active involvement in learning activities, innovative ways to enhance understanding of basic concepts and changes to the time-frame and assessment process.

5.3 The learning environment in statistics distance education

Moore (1997) claimed that the current reforms in statistics education are based on a constructivist view of learning. In section 2.3.2, the literature relating to constructivism in distance education was discussed and it was noted that, depending on the point of view of the commentator, traditional distance learning can be said to either be based on a constructivist theory or based on an "information transfer" (behaviourist) model.

Several leading statistics educators (Moore, 1997; Chance, 1997) are advocating spending less time in lectures and more in a variety of other learning and assessment tasks. Chance (1997) commented:

> I think it is important for the students to learn to identify the components of an effective statistical analysis or explanation for

> themselves. I want students to do much of the discovery for themselves, because what students construct for themselves, they will understand better and remember longer. (p. 7)

Since distance education students do spend more time on a variety of other activities such as making their own notes, working through examples etc. and rely on their own cognitive efforts to gain a grasp of a subject, it can be argued that they are actively constructing knowledge. However, active learning, as advocated in constructivist learning theory, will not necessarily happen in a distance environment any more than it will necessarily happen in a classroom or university setting. Distance students, if they have the time and interest, can certainly learn this way. With adequate resources supplied by the institution, a variety of interactive and meaningful activities can lead students through this process. Assessment tasks can be better designed to measure the degree to which students demonstrate a deep understanding and increased research could provide empirical evidence of such learning.

However, two other important characteristics of effective learning which must also be considered are motivation and metacognition (Young & Marks-Maran, 1998). In contrast to first year mathematics students (Anthony, 2000), many of who appeared not to have the metacognitive strategies required for independent learning, the older age and more life experience of Open Polytechnic students might stand them in good stead for this type of learning. Indeed, Moore (1997) claimed, with reference to learning statistics, that "distance learning has proved effective for mature and motivated students; it works much less well for relatively immature and less motivated students we often see in first courses" (p. 134). In keeping with the findings of White (1997), there was certainly much evidence of both self-knowledge of cognition and self-regulation of cognition in this group of distance students:

> *"I am a visual learner."*

> *"I'm going to set myself goals and keep focused on the target dates."*

Further evidence of the high levels of metacognitive strategies employed by these

students was obtained from the responses given when the interviewed students were asked what advice they would give to students about to start this paper. Student responses also indicated high awareness of a range of help-seeking and revision strategies. The following responses were obtained:

- *Ask around your networks and see who might be able to help if you get stuck*
- *Don't get too flustered if you don't understand everything at first - it will slowly sink in. Keep at it. Do a little every day rather than a big session once a week.*
- *Be well-organised, manage your time well. Do lots of practice exercises.*
- *If you are concerned about your maths, revise first. Use the exercises in the Study Guide and the Tutorial Notes.*
- *Don't panic, have a strict routine, allow plenty of time, be determined.*
- *Go to the tutorial, use the on-line forum, if you get stuck contact your tutor.*
- *Try to apply it - look at real life situations. Persevere - that's the main thing.*

Many of the students were also highly motivated, despite reservations about their mathematics. A typical comment from a beginning student was:

> *"I'm determined to finish, and excited, but also apprehensive and slightly stressed."*

Taylor (1996) suggested that two important features of successful learning were the ability of the students to co-ordinate metacognitive strategies with their goals; and the ability of students to be flexible in their approaches to learning, so they could tailor their approach to the demands of the particular learning environment. Placing high value on the learning of statistics, being motivated to succeed, albeit with reservations

about mathematical ability, and demonstrating good knowledge of metacognitive strategies appear to be characteristics of many successful students in this course.

However, to some extent, students' ability to adopt a deep approach to learning may have been hampered by lack of active learning materials, too short a time frame and a rigid assessment programme.

Current learning theories, such as social constructivism, give a central role to language in an effective learning environment. Social constructivism "assumes that language is used for negotiation of meaning and conceptual delimitations" (Kanuka & Anderson, 1998, p. 66). The lack of opportunity for group activities, as described in the previous section, is a major problem for distance educators. As discussed previously, research findings make it unlikely that computer technologies will enable beginning students, who rarely know another member of the class, to effectively work together on statistics projects in the near future. Similarly, there is little opportunity in distance education for oral discussion and presentation, although on-line forums and chat rooms do allow students to discuss problems electronically. The use of these methods to discuss statistics problems are not ideal, however, as the students are limited to the written word, use of symbols and diagrams are not possible and facial expressions and body language are absent.

The majority of students doing Statistical Analysis, did not take advantage of using the on-line forum and those that did mainly used it to introduce themselves to other students and to ask an occasional question. This was in keeping with the findings of Kanuka and Anderson (1998) who found "the greatest value of the online forum was the ability to share and receive information, as well as to *network* – not to construct new knowledge" (p. 71).

Within the discussion on the learning environment in distance education, the role of the teacher should not be overlooked. Garrison (1993) noted that "although the learner is ultimately responsible for learning, educationally the quality of that learning experience is established through the proactive interaction and guidance of a teacher" (p. 204). For statistics teachers this includes one-to-one tuition with students to clarify

key points, to help the student overcome misapprehensions, to provide motivation and encouragement, to assist development of learning strategies and to provide support for the student in their studies. Evidence that the teachers in this course were able to fulfil this role were apparent:

> *"Tutor assistance was vital. Due to my serious lack of mathematical knowledge, I was constantly in need of help, even to understand what part of an equation needed to be dealt with first."*

> *"My tutor always provided helpful advice and comments and was really positive."*

It appears then, that while active learning of statistics can take place in a distance learning environment, the social aspects of learning are still limited by available technologies. Motivation and metacognitive skills have been shown to support students' construction of knowledge and these two characteristics were apparent among many of the students in this study.

5.4 Delivery modes in statistics distance education

As technology improves, the variety of options for students learning statistics at a distance will increase. There is evidence from this research that students appreciate a variety of media:

> *"Having a range of things to draw on helped my learning - videos, tutorial notes, tutorial, textbook, Study Guide".*

Some of these options will now be discussed in more detail.

Video

Although Moore (1997, p. 131) noted that "even excellent video presentations have limited cognitive impact" and "video leaves its viewers passive", he saw some value in showing students real people using statistics in their communities. This was perceived as a means of changing attitudes and motivating students, but regarded as an inferior method of teaching statistics. While video is probably not a good option for face-to-face tuition, it does have advantages for distance students. It can familiarise students with the spoken language of statistics, it can explain processes visually in an effective manner and it can demonstrate real situations. Petocz (1998) concluded that video is best used in conjunction with other media and support systems and can be a useful addition to a multimedia package.

Students in this project enjoyed the videos, while acknowledging the passive learning taking place:

> *"Extremely effective, interesting topics, appropriate language and presentation, very enjoyable. It helped round out my understanding - it was a more passive way of learning when I could just sit back and watch."*

A disadvantage of using videos is the production or purchase cost and the need to update them every few years to avoid a dated appearance.

Textbook

Sowey (1998) discussed the role of the statistics textbook and noted that rarely were students asked for their opinion on which one to use. Distance education students use the textbook differently from other students. Students attending lectures will use the textbook as an adjunct to their lecture notes and McAlevey and Stent (1999) found students ranked the quality of the textbook as a low 36th out of 43 items relating to the characteristics of good teaching. They suggested that the textbook was of limited help to their students when difficulties arose and attributed this to the abstract nature of statistics. However, for distance education students in this course, the textbook is

their primary source of information relating to the subject being studied. It is therefore vital that the textbook meets the needs of the individual students:

> The more closely the knowledge a textbook assumes matches what a particular student actually knows, and the more closely its expository style matches the way that student thinks, the more speedily that student is likely to form a firm understanding of the subject matter. (Sowey, 1998, p. 152)

Given the diversity of the distance education students, it is not surprising that there was a wide range of opinion on the effectiveness of the textbook used in this study:

> *"Very easy to follow for someone who has never studied statistics."*

> *"Did not find it helpful in explaining methods - not in lay terms."*

Surprisingly, only one student mentioned the American focus of the textbook being used, suggesting that questions relating to SAT scores and baseball statistics may be readily transferable to topics within the experience of New Zealand students. This is in keeping with McAlevey and Stent's (1999) findings that students placed low importance on the application of statistics to relevant areas, but seems to be in contrast to the calls from leading statistics educators (Snee, 1993; Sowey, 1995) to use data which is both real and relevant to students.

One aspect of the textbook used in this course which provoked several comments was the need for more worked examples. Garfield (1995) noted that having students read worked examples may be more effective than having them do exercises for themselves, as students need to be exposed to the same idea being presented in a variety of contexts. Also, Anthony (1994) while discussing the role of the worked example in learning mathematics noted that "recent research has suggested that a greater emphasis on worked examples may facilitate learning and subsequent problem solving to a greater extent than actually engaging in the solution of the problem" (p. 129). Typical comments from students were:

"The answers to the exercises in the book were very short and there were times when I could not work out how to get the answers."

"More involved answers to the exercises were needed, explaining exactly how the answer was arrived at."

"Clearer and fuller examples to work through were needed."

While the accompanying Study Guide went some way to addressing these deficiencies, there appears to be a need that is not currently being met by statistics textbooks:

"The exercises in the Study Guide were excellent for helping in areas that were difficult to understand".

"The Study Guide showed different ways of applying the methods."

Sowey (1998) noted three inherent limitations of a textbook - it is non-interactive; it is content inert (i.e. the content remains fixed until the next edition); and it is static (i.e. its pages are in a fixed order and its graphics are still). Given these limitations, and the advances in technology discussed below, Sowey asks if the textbook has a future. He concludes that it does but calls for student input into the choice and a wider range of statistics textbooks in terms of content and style.

On-line texts

There are a number of on-line statistics texts now available which, although not necessarily designed for distance students, appear to offer great potential for the distance education market. The advantages of these sites are that they can continually evolve as technology and learning theories develop. In addition, they can provide interactive components which are invaluable in the learning of statistics, they can provide examples specific to a variety of student areas of interest and link with other useful sites. Disadvantages for distance education include the cost of internet use, the

lack of appeal in reading from a computer screen and technological problems such as students having the necessary software on their home computers to allow speedy download.

There was evidence that some students in this course were using some of the recommended sites and searching for other sites. A more comprehensive listing of useful links would be an added resource for students.

In summary, the comments of Cobb (1997) are particularly pertinent:

> There are clearly many media for any instructional job, but this does not mean they all do it at the same level of efficiency whether economic, logistic, social or cognitive. It is precisely the job of the media specialist to know the range of media that can realize any instructional methodology, and to find the ones that best match all the resources of their target learners. (p. 13)

This seems to be especially true for distance learners and, given the range of resources available for statistics teachers, more research into the effectiveness of different learning media is still needed.

5.5 Student support in statistics distance education

Student support within statistics distance education will be considered under the three headings used in the literature review, section 2.3.5, namely academic support, systemic support and social support. The literature review revealed that there is evidence that student support will continue to be a vital part of distance education, even with the introduction of on-line and technologically enhanced courses.

Academic support

For students learning statistics at a distance, the role of the tutor in providing support is as vital as in any course. However, there is evidence that some students are still reluctant to seek the available help:

> *"I didn't have much tutor contact. Normally I'm pretty independent - I didn't want to seem as though I was hassling him. I didn't want to appear too dumb or have him say 'Look haven't you read this?'"*

> *"I'm shy and don't usually phone up. It's hard unless you know the faces of your tutor."*

Provision of academic support for students learning statistics at a distance can be done several ways - telephone, email, letter, electronic forum or chat room etc. Some of these methods will now be discussed in further detail.

The use of the free phoneline is still one of the most common ways for students at The Open Polytechnic to contact their tutor. The advantages are that the student can get an immediate answer (if the tutor is in to take the call), the answer can be directed personally to the students and the time taken can be short. The informal and personal style of telephone calls can be especially appealing to adults. Coulter (1989) commented on the higher degree of control the student has in a telephone call and argued:

> It might well be that telephone tutoring encourages mutuality between two adults who both teach and learn from each other rather than engaging in the more common dominance-submission patterns of instructor and student. (p. 15)

Tutors in the course under study usually phone all students at the beginning of the semester to introduce themselves. It is believed that by making the initial contact, students are encouraged to approach their tutor when they have difficulties. This

position is supported by the research literature, for example, Hipp (1997) noted that a number of studies have confirmed that "students want more support in the form of personal contact" (p. 44). Disadvantages with providing support by telephone include the lack of any visual component to the answer and lack of non-verbal cues which often means the tutor is unable to gauge whether the student has understood. For overseas students, it is costly and often needs to be made at an unsuitable time. For a subject involving difficult concepts some students find it hard to put their problem into words:

> *"It was hard to explain my difficulties over the phone."*

However, many students find the phone a useful support mechanism, not just for academic advice but also for personal contact and as a means of addressing affective issues:

> *"Ringing my tutor to chat about problems was helpful and reassuring."*

Email is an increasingly common way of contact. This can be time-consuming for the tutor, limited in use of symbols and diagrams and often involves a delay for the student. However, shyer students may prefer this method and it does allow overseas students or those working in the evenings to send their question at a time suitable to them. One interviewed student commented:

> *"I found emails easier - you get the answer back and you can think about some of the issues."*

To save time answering the same question more than once, the question and answer can be put on the electronic forum. This saves repetition but lacks any personalised reply and may even embarrass the student (although no names would be used). It does, however, mean that students who would not normally ask a question, have access to both question and answer.

A synchronous chat room has worked successfully in some Open Polytechnic courses. This has the advantage of social contact for students and immediacy of answers. However, it must be well managed and, if it is to fit in with the study times of students, requires tutors to work more irregular hours.

Mail is still an effective way of answering questions which require explanation of workings and diagrams. The disadvantage is the time delay, and especially in one semester courses, means that valuable time elapses before the reply is obtained. Since D. Roberts (1996) and Inglis (1998) argue that speed of feedback is important, this method may be superceded by electronic means in the near future. Nevertheless, this method is still predominantly used by the Open Polytechnic when providing feedback on assessments. Little is known, however, about how this sort of academic guidance is used by the student and only one student in this study mentioned it, noting that:

> *"I received good feedback from my assessments."*

Conference calls are another possibility. They again allow social contact but it may be hard to provide suitable information to students who are working at different paces and are at different skill levels. There is a limited number who can participate at once so involving all students can be time consuming.

Videoconferencing is frequently used in distance education in the United States. Burge (1995) noted that this medium often encouraged a lecturing style of presentation and saw the need for educators to find ways "to use the somewhat limited visual channel to enhance the cues necessary for communicating ideas and understanding the feelings behind the expression"(p. 159). Students also must learn ways of maximising the use of this medium.

A recent innovation is the use of an electronic whiteboard. This can be effective for demonstrating diagrams but disadvantages include internet and software costs for students.

The type of academic support most often called for by the students in this course was face-to-face contact. It seemed that, although choosing to do this course by distance, they felt the need to have someone explain the concepts to them as well. The advantages of having tutorials include being able to address specific issues requested by students, being able to demonstrate concepts using diagrams and symbols and, for students, being able to form a personal relationship with their tutor. The disadvantages include the cost for both students and The Open Polytechnic and the difficulty in pitching the tutorial at a level suitable for both proficient and struggling students.

When choosing a mix of student support mechanisms for a distance education statistics course, there is a need to address both cognitive and non-cognitive issues. A variety of media should be made available so the student can choose one or more which suit their lifestyle and their learning style.

Systemic support

With the introduction of more on-line courses, the importance of good technical support for both students and tutors will increase. Although 42% of Open Polytechnic students currently have internet access (The Open Polytechnic, 2001), the percentage of students studying Statistical Analysis who have access is probably nearer 75%. The research responses suggested that this group of students had few technical problems although one noted:

"The CD-ROM didn't work on my new computer - I don't know why."

Currently tutors are often asked to assist students with problems but there is a limit to the effectiveness of this and more specialized help would be desirable. Students who are using the internet for links to statistics education sites, data sites and for interactive activities, as well as using statistical software and submitting assessments on-line, will undoubtedly have problems from time to time. Round the clock access to help is needed if an institution is to adequately meet the demands from a world-wide body of students.

Social support

Some responses to the beginning questionnaire mentioned family support as one of the ways they would cope with their statistics study. However, when the final questionnaire asked "What sorts of things helped?" no students mentioned their family or other social support networks. This omission was surprising, but it could be that for this group of students, family support was taken for granted. As most were experienced students, it is possible that their families had become used to them studying and a good routine had been established. Among the interviewed students, two talked about discussing course content with their spouses, although neither obtained any substantial help this way. The interviewed male students with families spoke of minimising the impact of their study on their family lives and keeping their study to set times each week:

> *"Probably the hardest thing with distance learning is getting the balance of work, family life and study."*

Although no students appeared to have worked with other students doing the same course, some noted that the on-line campus forum was a valuable mechanism for reducing isolation:

> *"It was good to read in the internet forum that other people were struggling too. This gave me more confidence to plough on through."*

5.6 Women in statistics distance education

Vere-Jones (1995) commented:

> A very special feature of statistics...is that it breaks away from the vision of mathematics as a male-oriented subject...Traditional mathematics teaching formed part of an education programme which acted to perpetuate a tradition of male dominance. Statistics does not carry the same historical loading. (p. 14)

It is not surprising then that there appear to be few gender-specific statistics issues raised in the literature on learning statistics. There are, however, some ideas relating to learning at a distance and the way people come to know that are worth exploring in relation to learning statistics.

As the research literature claims that women often prefer a collaborative approach to learning, the forum entries for the semester were examined. There was little evidence that women used it more than men. Women also attended the tutorials in a similar proportion to their numbers in the class, a finding in contrast to Kirkup and von Prummer (1990). Nevertheless, the idea that women react differently from men to various forms of support is important when considering support options for a distance education statistics course and has yet to be explored in the statistics learning environment.

The one issue that appeared to differentiate gender was that of confidence. Several women said they did not feel confident beginning the course, whereas only one man did. Hipp (1997) also noted the lack of confidence in women distance students and proposed that "teaching staff in individual subjects need to be encouraged to give positive and constructive feedback on students' work to ensure confidence is enhanced rather than further eroded" (p. 47).

The literature review (section 2.3.6) discussed the work of Belenky et al. (1986) and the way women learn. Gunn (1999) noted the lack of work in this area in statistics education research and also claimed that the "emphasis on constructivism (in its various forms) means that scant attention is given to the place of informal knowledge or the role of intuition, imagination and inspiration in the construction of knowledge" (p. 248).

While the primary purpose of this research was not to investigate the ways students came to know about statistics, it was of interest to examine the statements of this group of students in relation to Belenky et al.'s (1986) 'ways of knowing'. The following table exhibits some examples found in the interview transcripts or questionnaire responses. The definitions of the various ways of knowing are taken

from Ocean (1998) and the examples are attributed to either female (F) or male (M) respondents. The examples were chosen without knowing the gender of the respondent - these were determined subsequently from the original questionnaires and transcripts.

Ways of knowing	Examples
Silent knowing Knowing is subliminal. It is not articulated and the knower does not believe that she can learn from her own experience.	When I was at school we didn't ask questions. (F)
Received knowing The knower listens to the voice of authority. There is only one right answer which the teacher will dispense.	Statistics can be difficult if you have a bad memory. (F) When assessments were returned, there was no answer sheet to see what the correct answers were (F) The maths made it difficult and knowing which formula to use. (F)
Subjective knowing Truth is a private and individual matter for everyone. Abstraction, logic and analysis are distrusted.	Statistics is not an easy subject to learn even after you master formulas. I now know that in maths 4 + 4 can equal 9. (M) I came unstuck with probability - you know, the basis of it all. I'm arrogant enough to question that the theories are right. (F)

Procedural knowing (separate) Knowing is based on the use of impersonal procedures to establish truths. The solution is obtained in a structured, algorithmic way, stripped of any context.	I took the view that if I could understand the theory and apply the right formula I would get through the process. (M) There are many methods but one needs to choose the right one to achieve the result one wishes. (M)
Procedural knowing (connected) Personal experiences are built on. Context is important. Connected knowing is complex, related, considers many things simultaneously.	Statistics can be used to provide an insight into any situation from Shakespeare to contaminated water to the Challenger disaster. (F) There are many facets to statistics and all play an important role in making a conclusion. (F)
Constructed knowing Both separate and connected knowing are used. Answers are dependent on the context in which questions are asked and on the frame of reference of the asker.	I guess I see it like a good crossword - the components eventually linked although some took a bit of working out along the way. (F)

Although Belenky et al. (1986) found that there were few women in their survey demonstrating the silent way of knowing, Erchick (1996) noted that among women interviewed about their experiences of mathematics, this way was common. She commented that the traditional mathematics classroom often rewards students for their silence, as they place few demands on teachers. For these types of knowers "survival depends on blind obedience; trying to know "why" is neither important nor possible" (Erchick, 1996, p. 111). Belenky et al. (1986) found that silent knowers often came from violent, abusive backgrounds or social isolation while Fiore (1999) noted that for some students "math anxiety resulted from past verbal or physical abuse, in particular,

abuse by a teacher or a parent while doing mathematics" (p. 1). The idea that past experiences in the home or classroom could have a dramatic impact on the way a student learns mathematics or related subjects is important and may help explain why some students, despite a lot of support, "just don't get it".

Within distance education, it is difficult to assess whether students are 'silent knowers' or just getting on with the job independently. Without contact with the student, the distance educator has difficulty in gauging the ability, understanding and support needs of the students. Some students never contact their tutor and never communicate on-line. Some, but not all of these students, may be able to be classed as 'silent knowers'. These are likely to be the people who return poor assessments, and who remain 'silent' despite pleas from the tutors for them to ring and get help. To be able to provide a suitable support system, there is a need for a method of identification of students for whom silent knowing is the only way of attempting to learn statistics. As Erchick (1996) noted that for many capable students "it was only in mathematics that they found themselves maintaining positions of silence" (p. 112), this task becomes even more challenging for distance educators.

There has been some debate concerning the difference between separated and connected knowing in relation to the learning of mathematics. Separate knowing is characterized by such things as rigour, logic, certainty and structure (Becker, 1995). In contrast, the connected knower uses shared experiences and "explores what actions and thoughts lead to the perception that something is known" (Becker, 1995, p. 166). While not being gender specific, it is thought that the two types of procedural knowing may be gender related, with more men separate knowers and more women connected knowers. The "connected way of being for women comes, it is argued, out of a life in which one's relationships with others and the well-being of others are a crucial part of personal development" (Kirkup, 1996, p. 151).

Becker (1995) noted that among her survey of graduate mathematics students, many mentioned being attracted to mathematics because they liked the logic and problem solving aspects and because they could tell if the problem was solved and asked "are women in mathematics more likely than non-mathematicians to be separate knowers

and thus be attracted to the subject because, at least at this early stage, they perceive mathematics to be an objective discipline in which they can find absolute truth?" (p. 171).

There was evidence of this style of thinking from one of the women interviewees:

> *"I liked having the practical things that you nutted through (rather than write 200 words) and came to the conclusion at the end."*

Nevertheless, students must come to realize that in statistics, particularly inferential statistics, all answers are tentative, dependent on certain assumptions and have meaning only in the context they are derived from. Clayson (1998) commented "[Students] must accept ambiguity and uncertainty as givens and abandon the notion that there is such a thing as right or wrong answers independent of context" (p. 1075). As Becker (1995) argues that "the goal of separate knowing is to be absolutely certain of what is true. It is better to eliminate a possible truth than to accept as true something which later may prove to be false" (p. 166); it may be that separate knowers would find statistical concepts hard to grasp. Given the uncertainty in statistics, and a possible gender link with ways of knowing, could this be an explanation of why girls appear to be more attracted to learning statistics than pure mathematics? (32% of year 13 students taking mathematics with calculus in 2000 were girls, whereas 46% of those taking mathematics with statistics were girls (Ministry of Education, 2001)).

The best example of constructed knowledge came from a forum entry (cited here with permission of the author):

> *"I have come to the conclusion that statistics is like the 3-D pictures my daughter brought home from the library: when you first dive into it there is just so many new complex concepts facing you and it all seems such a massive complex body of knowledge. However, when you pull back slowly and look at the big picture, changing your focus, suddenly it all becomes so clear it's amazing. Just like when you finally see the hidden image in those 3-D*

pictures. And even then, it's so easy to lose the image again if you don't concentrate and practice putting together all the new skills and concepts."

This student is trying to see the big picture, to connect the body of statistics knowledge to her previous knowledge and to adjust her focus. Yet she knows that to do this she needs new skills and that she will have to practice them, demonstrating a combination of connected and separate knowing, within a given context.

Within statistical educational research, there appears to have been little work done on ways of knowing, as described by Belenky et al. (1986). Given the findings from this area of exploration in the learning of mathematics, it appears to offer an opportunity for research which could add valuable information to the literature on learning statistics.

5.7 Revisiting two adult education models

The complex contextual nature of learning was emphasised in the two models of adult learning discussed earlier (section 2.4). They will now be reconsidered in the light of findings from this study.

Lyman (1999), although discussing Web-based learning, presented a model of learning that has wider implications for mixed media distance learning packages. She noted the complex interaction of learner characteristics, learning goals, learning skills and strategies and the nature of the media in her Model of Situated Learning. The first two of these groupings build on many of the findings of the research into adult learning, including the concept of andragogy. In the context of this study, cluster three, learning skills and strategies can be broadened to include not only technological skills but also metacognitive skills and learning strategies; while cluster four, the nature of the media, can be broadened to include the variety of media offered in this, or other, statistics courses.

Looking at the four clusters individually, evidence can be found from the results of this study to support such a contextual model of learning.

Learner characteristics.

Although many of the students in this study were highly motivated, as discussed previously, some brought to their study experiences of past learning, particularly of mathematics, which may have hindered their ability to cope with a statistics course. For this group of students, not all life experiences provided a basis on which to build an understanding of statistics. Motivation for some, came via their desire to do well, even in a course that they were apprehensive about and one which they would not have chosen had it not been compulsory. Motivation, for these students was both internal and external. For others, lack of internal motivation appeared to be due to past experiences of failure in mathematics or statistics, a lack of metacognitive knowledge and a lack of knowledge about the meaning of the term statistics. This variation in exposure to statistics and understanding of the term statistics, was a feature of the beginning questionnaires.

As "motivations of adult students are strongly tied to the value they place on an educational experience" (Verduin & Clark, 1991, p. 24), it was encouraging to see that most students in this study placed a high value on the study of statistics, both before and after completion of the course. There was also evidence of an alignment of strategies and motivation to succeed, as discussed by Taylor (1996).

Some students appeared to be self-directed learners, or at least planned to be before the course began. This was demonstrated by those students who clearly saw the responsibility for passing the course as their own and who re-organised parts of their lives to achieve this end. Nevertheless, within study of a compulsory statistics course which many students would not choose to do, self-direction was likely to only be possible for those students whose readiness to learn, in terms of basic mathematics ability and willingness to adopt new concepts was strong. Many students, for whom self-directed learning was possible in other areas, may have found that they needed more direction when it came to learning statistics. Learning styles appeared to differ considerably, as expected in a group of people of varying ages, occupations and life experiences. Consequently the way students used their materials and the way they perceived their worth also varied.

Learning goals

The majority of students taking Statistical Analysis, do so because it is a compulsory paper for their degree. Only occasionally does a student take this paper with an intrinsic personal goal in mind. Although much of the literature on adult learning suggests that for mature learners the goals of learning should be open to negotiation, the rigid assessment programme offered by most tertiary institutions and the need for one set of learning goals for all students hinders this. Nevertheless, within such assessment programmes there is room to develop the understanding of individual students. For example, Chance (1997) argued that "students need to receive feedback, not only on their exam performance, but also constructive indications of their strengths and weaknesses, guidelines for improving their understanding, and challenges to extend their knowledge" (p. 1). Chance (1997), Garfield (1994) and Hubbard (1997) have all argued convincingly for the assessment programme in statistics to change, to include assessment of skills such as interpretation, evaluation and communication. Within a distance environment, even with technological enhancements, some forms of assessment will present a challenge to educators. However, continual efforts must be made to develop methods which will reflect a variety of learning goals, including both those of external stakeholders (institutions, employers etc) as well as those of the students.

Learning skills and strategies

Lyman (1999) argued that for internet learning to be successful, students will need appropriate and effective skills. This heading can apply equally well to students using multi-media packages in distance education. Not only must students learning statistics at a distance have adequate computer skills to allow statistical analysis, graphical display and suitable presentation of their findings, but they must develop their metacognitive skills to enable them to use a variety of media forms to monitor and enhance their understanding. This will require greater information management skills than was previously required for a course which used only written resource materials. The variety of materials provided received positive comments from the students and no students mentioned the possible overload of resource materials.

Lyman (1999) noted that "learners confronted by challenging tasks typically welcome redundancy of information within multiple forms" (p. 106) and this appeared to be supported by this study.

Nature of the media

Lyman (1999) noted that the internet provided the opportunity to address barriers to education typically faced by adults. These included situational barriers such as time, money, lack of transport, lack of childcare etc; and institutional barriers such as knowledge about available courses and unfamiliarity with institutional processes and structures. However, she also noted that technology comes at a personal cost to the student and that much time can be wasted attempting to get the computer working properly and in finding required information.

In the context of this study, the nature of the media can be taken to mean the variety of learning materials provided - not just the internet, but the textbook, videos, on-line forums etc. The advantages and disadvantages of each, discussed previously, must be taken into account when designing a statistics course for distance learners.

In summary, Lyman's (1999) Model of Situated Learning has wider applications than just the Web-based learning she designed it for. The model is shown here again, with additional issues added in under each heading, based on the findings of this study and the literature relating to learning statistics at a distance.

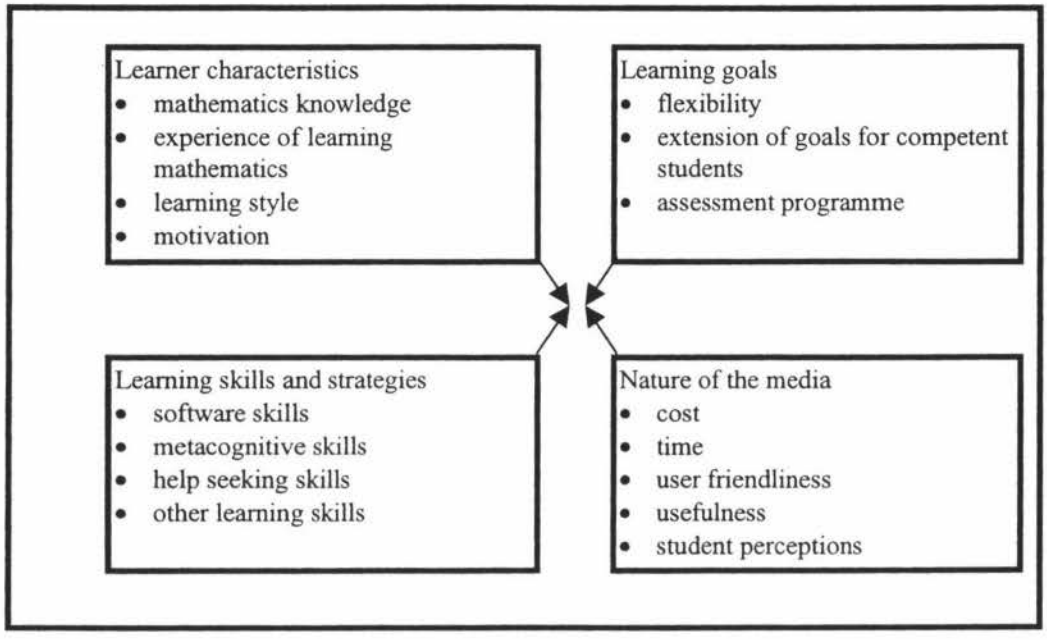

Figure 4: Adaptation of Lyman's Model of Situated Learning

The second model considered in section 2.4 was Ramsden's (1992) Model of Student Learning in Context.

Ramsden (1992) claimed:

> There is a large body of evidence indicating that some central goals of higher education - students' understanding of key concepts and ways of thinking in a discipline, and the development of abilities to integrate theoretical and practical knowledge in professional subjects - are by no means always achieved. (p. 82)

The literature has shown that the central goals are frequently not achieved in statistics education (e.g. Gardner & Hudson, 1998) although Gordon et al. (1996) noted that despite a lack of understanding, good grades could still be obtained. Consequently, Ramsden's model which shows how students' perceptions reflect the interaction between the learning environment, as defined by course structure and teaching methods, and previous experiences, seems particularly relevant. Student perceptions

influence the choice of approach to learning and therefore the outcome. Within this study, it was noted that previous learning experiences, particularly of mathematics, strongly influenced some students' perceptions of statistics and the way they went about learning statistics and completing the assessment tasks. For other students, their orientation to study, including motivation and metacognitive skills overcame doubts about their mathematical ability, and they clearly articulated their perceived responsibility for their own learning.

It is apparent from the model that three institutional factors - teaching, curriculum and assessment are influential in the students' orientation to study and their perception of the task requirements. If the aim of a statistics course, taught in a distance environment, is to encourage a deep approach to the learning of statistics, these three factors are of primary importance. However, Gordon (1993) noted that:

> The learning of statistics necessitates deep and surface approaches executed in a complementary, rather than contradictory, manner to take into account two distinct and identifiable aspects of studying it. One aspect, dealing with the algorithmic component, involves the process of recognising, applying and remembering mathematical techniques and skills. The other comprises an interpretative component and entails analysing the problem, inferring a suitable technique for solving it, and clarifying the result. (p. 36)

In this study, the course Statistical Analysis had learning outcomes in line with the reforms suggested by leading statistics educators over recent years, suggesting that the curriculum needed few changes. However, the assessment programme and the teaching methods need consideration, if they are to help the students overcome negative perceptions of statistics based on previous experiences and hearsay and to send the correct messages to students about the aspects of statistics which we most value.

However, not all interventions will be successful as the students' approach to learning will also be influenced by factors outside the control of the teacher and institution.

Learning must be seen as the result of complex interaction of a number of factors - some within the control of students, some within the control of educators and some due to social, cultural or educational influences within our society.

Chapter 6: Conclusion

6.1 Summary of findings

This research set out to record perceptions of students studying statistics in a distance environment, using a qualitative approach based on questionnaires and interviews. A holistic approach was taken, with both cognitive and affective issues being of equal importance. The main findings were as follows:

Most students were apprehensive about beginning their statistics course but were also determined and focused and most were confident about passing the course. Students who were apprehensive, or in a few cases daunted or overwhelmed, attributed this mainly to the perception that statistics was a mathematical subject. Many were aware of their own weak mathematics background and made efforts to upgrade their knowledge before commencing the course. Anxiety was observed, but it did not appear to be as extensive as has been reported in overseas studies. The need to identify and address anxiety remains a challenge for the distance educator.

Students almost universally saw value in learning statistics before the course began, although there was obviously some confusion in their minds as to what statistics was all about. Before the course began they frequently mentioned mathematics and formulae as being an important part of statistics but after the course these comments had been replaced by statements on the usefulness of statistics in their lives and society in general.

Distance students foresaw few problems in learning statistics in a distance environment, other than the normal problems of time shortage and family crises that are always present for adults who choose to study, work and raise a family simultaneously. Of the problems mentioned, the lack of mathematical knowledge was by far the most common. It appeared that although some students tried to address this problem, in general it was not adequately dealt with and some students struggled throughout the course because of it.

On completion of the course some students noted problems that they had not foreseen. Commonly mentioned was the difficulty in the concepts. This seemed to take many students by surprise, particularly students who had experienced a range of distance education courses and had achieved high grades in all of them. Students often commented that they felt the need for face-to-face contact, in order to have the concepts explained. Some made good use of resources in their community such as libraries, workmates or the internet.

There was a perceived inadequacy of immediate feedback and answers to questions, especially for those students who studied in the evenings. Among the resources made available to the students there was widespread enthusiasm for the videos, the Study Guide and the tutorial notes but less appreciation of the textbook and almost no use was made of the Media Activities book and CD-ROM.

Additional support mechanisms called for by the students included more face-to-face contact sessions and more worked examples. However, the majority of the students were satisfied with the mechanisms in place and often blamed themselves for not making more use of them.

Characteristics of successful students in this course were high motivation and determination, good knowledge of their own metacognitive and other learning strategies and good use of community resources to assist them in their learning. These characteristics were then considered in the complex context of distance learning. The interaction of learner characteristics with learning goals, learning skills and strategies and the nature of the media was considered in terms of Lyman's (1999) 'Model of Situated Learning'. Ramsden's (1992) 'Model of Student Learning in Context' was also considered as it emphasised how students' perceptions reflect the interaction between the learning environment and the students' orientation to learning, which is heavily influenced by previous experiences. Both were shown to be useful in explaining the complex relationships existing for mature-aged students learning statistics at a distance.

6.2 Recommendations for a successful distance education course

From the literature considered in relation to this research and the research findings themselves, a series of recommendations for a successful distance education statistics course for mature-aged students can be arrived at.

Mathematics

Although some leading educators have argued for more emphasis on the less mathematical aspects of statistics, there is no doubt that a certain amount of mathematics is required to cope with most first year statistics papers. To be effective, the course should either include basic mathematics or have a requirement for a certain level of mathematics for students entering the course. For older students, who may not have done mathematics for many years, a short refresher course should be available.

Affective issues

Affective issues such as anxiety, attitudes and beliefs need to be talked about and if possible assessed before the course begins. Although there is no current widely accepted instrument for assessing these in statistics courses, research is continuing in this field. Within a distance environment, these issues can be readily overlooked, but electronic forums and chat-rooms are now allowing students to talk among themselves about these issues and this development can only be beneficial.

Cognitive issues

The concepts involved in introductory statistics are often new to adults and are not easy to grasp. Attention needs to paid to the way these concepts are presented and continual reiteration and reinforcement of the basic ideas should be incorporated into the course design. The linkages between different concepts and techniques should be clearly and frequently demonstrated with a range of different representations and using a variety of media.

Content and structure

The content of a statistics course should heed the calls from leading educators for more emphasis on data production, communication and interpretation. The time-frame the course is run over, should, where possible, be flexible. Alternatively, it should be sufficiently long to allow distance students time to reflect on their learning and to incorporate the new concepts into their existing knowledge. Where possible active learning should be encouraged by innovative uses of software. Media examples should be incorporated into discussion and students encouraged to look at the way data is being used to argue for or against local issues. Assessment should be used to encourage a deep approach to learning and consequently an examination may not be an appropriate form of assessment for mature-aged distance students.

Delivery mode

To provide for a variety of learning styles, interests and lifestyles, the modes of delivery should be as varied and flexible as possible. Rather than concentrating solely one method of delivery, students are calling for a variety of modes - written, video, face-to-face and on-line. An effective distance course will use not one, but all of these. Whatever the resource used, it should be designed with the distance student in mind. A textbook designed for face-to-face course in a university is unlikely to be suitable for a distance student. Distance students may require more explanations and more worked examples in the resources than other students, who can see these demonstrated by the lecturer. Some face-to-face component is highly desirable, although this raises equity issues for students living in remote areas.

Support systems

Tutor support will continue to be an essential component of a distance education course. The tutor will fulfil the role as teacher, motivator, support person and counsellor and access should be available using a variety of media: phone, mail, electronic etc. Electronic forums and chatrooms should be used for social interactions between students but appear to have little value in collaborative activities at this level,

at the present time. In addition, technical support should be available for computer users and administrative support should be readily available for students who need to transfer, arrange examination venues etc. Awareness that the support needs of women students may differ from the needs of men students, particularly with regard to instilling confidence, is important.

6.3 Opportunities for further research

This project concentrated on the characteristics and perceptions of students who completed the course. There is considerable literature about why students fail to complete distance education courses in general but very little about why they fail to complete statistics distance education courses in particular. It is not known what proportion of those who did not complete this course withdrew for general reasons such as work pressures, illness etc. and what proportion withdrew largely because of anxiety or other affective issues or because of difficulty with statistical concepts. It is now important to look at the perceptions of these students and compare their metacognitive and other learning strategies with those of students who completed the course.

Within this piece of research there were several other areas touched upon where further research would add to the body of knowledge about learning statistics. One of these was the need to know how written feedback on assessments is used and the value of this in an age when electronic communication is becoming increasingly predominant. It would be of interest to know if students read the comments written on their assessments, if they reworked questions they did not get correct, if they sought additional resources or even if they reflected on their areas of difficulty.

There is also a need to record how distance students work with and react to technological changes in teaching statistics. It appears as though this group of students made little use of the interactive materials made available to them to assist their learning. Was this because of the design of the materials, lack of time or because the students saw little additional value in learning this way? Further research into technologically enhanced communications such as chat-rooms, forums etc. is also

needed and this should be done prior to introducing any electronic group activities for first year statistics students.

There is also a need for research into how students learn statistics and whether the emphasis on constructivism as a learning theory adequately explains how students, particularly women, come to an understanding of statistics. The categories of 'ways of knowing' derived by Belenky et al. (1986) may be useful here and work with these categories in learning statistics, to parallel that being done in learning mathematics, may be a useful area of research. Research which takes account of gender issues may have repercussions in designing course materials as well as support services for students of statistics.

6.4 Concluding thoughts

This research adds to the body of knowledge existing about the learning of statistics by concentrating on a group of students whose interests have been neglected in the past – mature-aged students choosing to learn statistics in a distance learning environment. It is important to address the perceptions and needs of these students as universities and polytechnics increasingly move towards on-line courses as a means of attracting students throughout the world to enrol at their institutions; and as the need for a tertiary qualification becomes a reality for many adults. By exploring how a group of adult students went about learning statistics at a distance and listening to their comments about the resources provided, the support systems needed and their strategies for successful completion, this project has provided course designers with information to design a suitable statistics course for mature-aged students learning at a distance.

References

Against all odds (1989). [A series of videos in 26 parts]. Santa Barbara, Calif.: Intellimation.

Amundsen, C. (1993). The evolution of theory in distance education. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 61-79). New York: Routledge.

Anderson, G. (1998). *Fundamentals of educational research* (2nd edn.). London: Falmer Press.

Anthony, G. (1994). The role of the worked example in learning mathematics. *SAMEpapers 1994*, (pp. 129-143). Hamilton, NZ: Centre for Science and Mathematics Education Research, University of Waikato.

Anthony, G. (2000). Factors influencing first-year students' success in mathematics. *International Journal of Mathematics Education in Science and Technology*, *31* (1), 3-14.

Bailey, D., Kirkup, G. & Taylor, L. (1996). Equal opportunities in open and distance learning. In R. Mills & A. Tait (Eds.), *Supporting the learner in open and distance learning* (pp. 129-145). London: Pitman.

Beaudoin, M. (1990). The instructor's changing role in distance education. *The American Journal of Distance Education*, *4* (2), 21-29.

Becker, J.R. (1995). Women's ways of knowing in mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 163 –174). London: Falmer Press.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R. & Tarule, J.M. (1986). *Women's ways of knowing: The development of self, voice and mind.* New York: Basic Books.

Bell, J. (1998). International students have statistics anxiety too! *Education*, *118* (2), 634-636.

Billard, L. (1998). The role of statistics and the statistician. *The American Statistician*, *52* (4), 319-324.

Box, G. (1990). Commentary on communications between statisticians and engineers/physical scientists. *Technometrics*, *32*, 251-252.

Bradstreet, T.E. (1996). Teaching introductory statistics courses so that nonstatisticians experience statistical reasoning. *The American Statistician*, *50* (1), 69-78.

Bratton, G. (1999). The role of technology in introductory statistics classes. *The Mathematics Teacher*, *92* (8), 666-669.

Bullen, M. (1995). Andragogy and university distance education. In D. Sewart (Ed.), *One world many voices: Quality in open and distance learning* (Selected papers from the 17th world conference of the International Council for Distance Education, Birmingham, United Kingdom, June 1995, Vol. 1, pp. 380-383). Milton Keynes: International Council for Distance Education and The Open University.

Burge, E. (1988a). Foreword in K. Faith (Ed.), *Towards new horizons for women in distance education: International perspectives*. London: Routledge.

Burge, E. (1988b). Beyond andragogy: Some explorations for distance learning design. *Journal of Distance Education*, *III* (1), 5-23.

Burge, E. (1994). Learning in computer conferenced contexts: The learners' perspective. *Journal of Distance Education, IX* (1), 19-43.

Burge, E. (1995). Electronic highway or weaving loom? Thinking about conference technologies for learning. In Lockwood, F. (Ed.), *Open and distance learning today* (pp. 151-163). London: Routledge.

Burge, E. & Haughey, M. (1993). Transformative learning in reflective practice. In T. Evans & D. Nation (Eds.), *Reforming open and distance education: Critical reflections from practice* (pp. 88-103). London: Kogan Page.

Burge, E. & Lenskyj, H. (1990). Women studying in distance education: Issues and principles. *Journal of Distance Education*, *V* (1), 20-37.

Burns, R. (1996). *Introduction to research methods* (3rd edn.). Melbourne: Addison Wesley Longman.

Burton, L. (1987). From failure to success: Changing the experience of adult learners of mathematics. *Educational Studies in Mathematics*, *18*, 305-316.

Carr-Chellman, A., Dyer, D. & Breman J. (2000). Burrowing through the network wires: Does distance detract from collaborative authentic learning? *Journal of Distance Education*, *15* (1), 39-62.

Chance, B. (1997). Experiences with authentic assessment techniques in an introductory statistics course. *Journal of Statistics Education*, *5* (3). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v5n3/chance.html

Chen, L. (1997). Distance delivery systems in terms of pedagogical considerations: A reevaluation. *Educational Technology*, July-August, 34-37.

Clayson, J. (1998). Confessions of a constructionist: Fifteen years of undergraduate interactions - for better or for worse. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 3, pp. 1075-1082). Singapore: International Association for Statistical Education.

Cobb, T. (1997). Cognitive efficiency: Toward a revised theory of media. *Educational Technology, Research and Development, 45* (4). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v1n1/cobb.html

Coulter, R. (1989). Women in distance education: Towards a feminist perspective. In R. Sweet (Ed.), *Post-secondary distance education in Canada: Policies, practices and priorities* (pp. 11-22). Athabasca University: Canadian Society for Studies in Education.

Crawford, K., Gordon, S., Nicholas, J. & Prosser, M. (1998). Qualitatively different experiences of learning mathematics at university. *Learning and Instruction, 8* (5), 455-468.

Crawford, K., Gordon, S., Nicholas, J. & Prosser, M. (1994). Conceptions of mathematics and how it is learned: The perspectives of students entering university. *Learning and Instruction, 4*, 331-345.

Daugherty, M. & Funke, B. (1998). University faculty and student perceptions of web-based instruction. *Journal of Distance Education, 13* (1), 21-39.

De Corte, E. (1995). Fostering cognitive growth: A perspective from research on mathematics learning and instruction. *Educational Psychologist, 30* (1), 37-46.

Diekhoff, G. (1996). *Basic statistics for the social and behavioural sciences*. Upper Saddle River, NJ: Prentice Hall.

Dunning, D.B. & Lai, C. (1998). Supporting the distance learning of the introductory business statistics course by telephone and e-mail. In L.Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 1, pp. 391-397). Singapore: International Association for Statistical Education.

Entwistle, A. & Entwistle, N. (1992). Experiences of understanding in revising for degree examinations, *Learning and Instruction, 2* (1), 1-22.

Erchick, D. (1996). Women's voices and the experience of mathematics. *Focus on Learning Problems in Mathematics, 18* (1, 2 & 3), 105-122.

Evans, T. (1994). *Understanding learners in open and distance education*. London: Kogan Page.

Falk, R. & Konold, C. (1992). The psychology of learning probability. In F. Sheldon and G. Sheldon (Eds.), *Statistics for the Twenty-First Century* (pp. 151-164). United States of America: Mathematical Association of America.

Ferris, M. & Hardaway, D. (1994). Teacher 2000: A new tool for multimedia teaching of introductory business statistics. *Journal of Statistics Education, 2* (1). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v2n1/ferris.html

Fiore, G. (1999). Maths-abused students: Are we prepared to teach them? *The Mathematics Teacher, 92* (5), 403-405.

Flavell, J. (1976). Metacognitive aspects of problem solving. In L. Resnick (Ed.), *The nature of intelligence* (pp. 231-236). Hillsdale, New Jersey: Lawrence Erlbaum.

Fong, G., Krantz, D. & Nisbett, R. (1986). The effects of statistical training on thinking about everyday problems. *Cognitive Psychology, 18*, 253-292.

Gal, I. & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Towards an assessment framework. *Journal of Statistics Education, 2* (2). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v2n2/gal.html

Gal, I., Ginsburg, L. & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal & J. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 37-54). Amsterdam: IOS Press.

Gall, J., Gall, M. & Borg, W. (1999). *Applying educational research: A practical guide* (4th edn.). New York: Longman.

Ganesh, S. & Ganesalingham, S. (1998). Teaching basic statistical concepts using computer display tools. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 2, pp. 1001-1007). Singapore: International Association for Statistical Education.

Gardner, P. & Hudson, I. (1998). *University students' ability to apply statistical procedures: A report on the learning to apply statistics project.* Melbourne, Australia: Monash University.

Garfield, J. (1994). Beyond testing and grading: Using assessment to improve student learning. *Journal of Statistics Education, 2* (2). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v2n1/garfield.html

Garfield, J. (1995). How students learn statistics. *International Statistical Review*, 63 (1), 25-34.

Garfield, J. (1997). Discussion on new pedagogy and new content: The case of statistics. *International Statistical Review, 65* (2), 137-141.

Garfield, J. & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for Research in Mathematics Education, 19* (1), 44-63.

Garrison, D.R. (1993). A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions. *Distance Education, 14* (2), 199-211.

Garrison, D.R., Anderson, R. & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *The American Journal of Distance Education, 15* (1), 7-23.

Garrison, D.R. & Shale, D. (1990). A new framework and perspective. In R. Garrison & D. Shale (Eds.), *Education at a distance: From issues to practice* (pp.123-134). Florida: Krieger.

Gillis, A., Jackson,W., Braid, A., MacDonald, P. & MacQuarrie, M. (2000). The learning needs and experiences of women using print-based and CD-ROM technology in nursing distance education. *Journal of Distance Education, 15* (1), 1-20.

Glesne, C. & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. New York: Longman.

Godden, G. (1998). Addressing the nurse's need for personalised tuition in a distance offering of introductory service statistics. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 3, pp. 1273-1278). Singapore: International Association for Statistical Education.

Goos, M. & Galbraith, P. (1996). Do it this way! Metacognitive strategies in collaborative mathematical problem solving. *Educational Studies in Mathematics, 30*, 229-260.

Gordon, S. (1993). Mature students learning statistics: The activity theory perspective. *Mathematics Education Research Journal, 5* (1), 34-49.

Gordon, S. (1995). What counts for students studying statistics? *Higher Education Research & Development, 14* (2), 167-184.

Gordon, S. (1997). Students' orientations to learning statistics - Profiles of experience. In F. Biddulph & K.Carr (Eds.), *People in mathematics education* (Proceedings of the 20th annual conference of the Mathematics Education Research Group of Australasia, pp. 192-199). Rotorua, NZ: MERGA.

Gordon, S., Nicholas, J. & Crawford, K. (1996). Psychology students' conceptions of a statistics course. In L. Puig & A. Gutierrez (Eds.), (Proceedings of the 20th conference of the International Group for the Psychology of Mathematics Education conference, Vol. 3, pp. 11-18). Valencia, Spain: Program Committee.

Grace, M. (1991). Gender issues in distance education – a feminist perspective. In T. Evans & B. King (Eds.), *Beyond the text: Contemporary writing on distance education* (pp. 56-76). Geelong, Vic: Deakin University Press.

Grote, B. (2000). *Student retention and support in open and distance learning.* Lower Hutt, NZ: The Open Polytechnic of New Zealand.

Gunn, S. (1999). Emerging themes in statistics education. In J. Truran. & K. Truran. (Eds.), *Making the difference* (Proceedings of the 22nd annual conference of the Mathematics Education Research Group of Australasia, pp. 246-252). Sydney, NSW.:MERGA.

Hartley, J. & Trueman, M. (1997). What's the bottom line? How well do mature students do at university? In P. Sutherland (Ed.), *Adult learning: A reader* (pp. 174-181). London: Kogan-Page.

Hawkins, A., Joliffe, F. & Glickman, L. (1992). *Teaching statistical concepts.* London: Longman.

Henri, F. & Haughey, M. (2000). Editorial. *Journal of Distance Education, 15* (1), i-ii.

Higgins, J. (1999). Nonmathematical statistics: a new direction for the undergraduate discipline. *The American Statistician, 53* (1), 1-6.

Hilgenberg, C. & Tolone, W. (2000). Student perceptions of satisfaction and opportunities for critical thinking in distance education by interactive video. *The American Journal of Distance Education, 14* (3), 59-73.

Hill, J. (1997). Distance learning environments via the World Wide Web. In B. Kahn (Ed.), *Web-based instruction* (pp. 75-80). Englewood Cliffs, NJ: Educational Technology Publications.

Hipp, H. (1997). Women studying at a distance: What do they need to succeed? *Open Learning*, June, 41-49.

Ho H., Senturk, D., Lam, A., Zimmer, J., Hong, S. & Okamoto Y. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education, 31* (3), 362-379.

Hogg, R. (1991). Statistical education: Improvements are badly needed. *The American Statistician, 45* (4), 342-343.

Holmberg, B. (1995). *Theory and practice of distance education* (2nd edn). London: Routledge.

Hubbard, R. (1997). Assessment and the process of learning statistics. *Journal of Statistics Education, 5* (1). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v5n1/hubbard.html

Inglis, A. (1998). Video email: A method of speeding up assignment feedback for visual arts subjects in distance education. *British Journal of Educational Technology, 29* (4), 343-354.

Jegede, O.J. & Kirkwood, J. (1994). Students' anxiety in learning through distance education. *Distance Education, 15* (2), 279-290.

Jonassen, D., Davidson, M., Collins, M., Campbell, J. & Bannan Haag, B. (1995). Constructivism and computer-mediated communication in distance education. *The American Journal of Distance Education, 9* (2), 7-26.

Kanuka H. & Anderson, T. (1998). Online social interchange, discord, and knowledge construction. *Journal of Distance Education, 13* (1), 57-74.

Keegan, D. (1993). Reintegration of the teaching acts. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 113-134). New York: Routledge.

Kember, D. (1994). The teacher is more important than the medium: Pre-packaged instructional materials are not axiomatic with surface learning. *Distance Education, 15* (1), 153-159.

Kember, D. (1995). *Open learning courses for adults: A model of student progress.* Englewood Cliffs, NJ: Educational Technology Publications.

Kirkup, G. (1996). The importance of gender. In R. Mills & A. Tait (Eds.), *Supporting the learner in open and distance learning* (pp. 146-164). London: Pitman.

Kirkup, G & von Prummer, C. (1990). Support and connectedness: The needs of women distance education students. *Journal of Distance Education, V* (2), 9-31.

Kirkwood, A. (1998). New media mania: Can information and communication technologies enhance the quality of open and distance learning? *Distance Education, 19* (2), 228-240.

Knowles, M., Holton, E. and Swanson, R. (1998). *The adult learner* (5th edn.). Houston, Texas: Gulf.

Konold, C. (1995). Issues in assessing conceptual understanding in probability and statistics. *Journal of Statistics Education, 3* (1). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v3n1/konold.html

Leder, G. & Forgasz, H. (1998). Tertiary mathematics: Perceptions of school leavers and mature-age students. In C. Kanes, M. Goos & E. Warren (Eds.), *Teaching mathematics in new times* (Proceedings of the 21st annual conference of the Mathematics Education Research Group of Australasia, pp. 311-318). Brisbane, QLD: MERGA.

Lentell, H. (1995). Giving a voice to the tutors. In D. Sewart (Ed.), *One world many voices: Quality in open and distance learning* (Selected papers from the 17th world conference of the International Council for Distance Education, Birmingham, United Kingdom, June 1995, Vol. 1, pp. 439-442). Milton Keynes: International Council for Distance Education and The Open University.

Li, N. Lee, K. & Kember, D. (2000). Towards self-direction in study methods: The ways in which new students learn to study part-time. *Distance Education, 21* (1), 6-28.

Lunn, D. (1998). An overview of statistical education at a distance. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 1, pp. 399-400). Singapore: International Association for Statistical Education.

Lyman, B. (1999). Internet-based learning: What's in it for the adult learner? In D. French et al. (Eds.), *Internet based learning: An introduction and framework for higher education and business* (pp. 97-118). London: Kogan Page.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30* (5), 520-540.

Maher, E. (1998). Does the delivery media impact student learning? A case study. *Open Learning, 13* (3), 27-32.

Martens, R., Valcke, M., Portier, S., Weges, H. & Poelmans, P. (1997). Research with interactive learning environments in three content domains: Descriptive statistics, continuous mathematics and substantive criminal law. *Distance Education, 18* (1), 44-58.

Machtmes, K. & Asher, J. W. (2000). A meta-analysis of the effectiveness of telecourses in distance education. *The American Journal of Distance Education, 14* (1), 27-46.

Marshall, C. & Rossman, G. (1999). *Designing Qualitative Research* (3rd edn.). Thousand Oaks, Calif.: Sage.

May, S. (1993). Collaborative learning: More is not necessarily better. *The American Journal of Distance Education, 7* (3), 39-49.

May, S. (1994). Women's experiences as distance learners: Access and technology. *Journal of Distance Education, IX* (1), 81-98.

McAlevey, L. & Stent, A. (1999). Undergraduate perceptions of teaching of a first course in business statistics. *International Journal of Mathematics Education in Science and Technology, 30* (2), 215-225.

McAlpine, I. (2000). Collaborative learning online. *Distance education, 21* (1), 66-80.

McCahon, R. (2000). How can we help? Supporting students in distance tertiary education: An evaluative study. *Journal of Distance Learning, 5* (1), 27-38.

McLeod, D. (1992). Research on affect in mathematics education: A reconceptualization. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). New York: MacMillan.

Merriam, S. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.

Merriam, S. (Ed.) (2001). *The new update on adult learning theory.* San Francisco: Jossey-Bass.

Mills, R. (1999). Diversity, convergence and the evolution of student support in higher education in the UK. In A. Tait & R. Mills (Eds.), *The convergence of distance and conventional education: Patterns of flexibility for the individual learner* (pp. 71-85). London: Routledge.

Ministry of Education. (2001). *Education statistics for New Zealand 2000.* Wellington: The Data Management and Analysis Division, Ministry of Education.

Minitab for Release 12, The student edition. (1999). [Computer program]. Addison Wesley Longman.

Moore, D. (1997). New pedagogy and new content: The case of statistics. *International Statistical Review, 65* (2), 123-165.

Moore, D. & McCabe, G. (1999). *Introduction to the practice of statistics* (3rd edn.). New York: W. H. Freeman.

Moore, M.G. (1986). Self-directed learning and distance education. *Journal of Distance Education, I* (1), 7-24.

Moore, M.G. & Kearsley, G. (1996). *Distance education: A systems view.* Belmont: Wadsworth.

Mosteller, F. (1988). Broadening the scope of statistics and statistical education. *The American Statistician, 42*, 93-99.

Navarro, P. & Shoemaker, J. (2000). Performance and perceptions of distance learners in cyberspace. *American Journal of Distance Education, 14* (2), 15-35.

Newstead, S., Hoskins, S., Franklyn-Stokes, A. & Dennis, I. (1997). Older but wiser? The motivation of mature students in higher education. In P. Sutherland (Ed.), *Adult learning: A reader* (pp.182-190). London: Kogan-Page.

Nunn, V. (1998). Motivational differences between OU, mature and traditional university students. *Open Learning*, June, 47-51.

Ocean, J. (1998). Identifying separate and connected knowing in mathematics education. In C. Kanes, M. Goos & E. Warren (Eds.), *Teaching mathematics in new times* (Proceedings of the 21st annual conference of the Mathematics Education Research Group of Australasia, Vol. 2, pp. 428-435). Brisbane, QLD: MERGA.

Onwuegbuzie, A. (1999). Statistics anxiety among African American graduate students: An affective filter? *Journal of Black Psychology, 25* (2), 189-209.

O'Rouke, J. (1999). Canaries in the mine: Women's experiences and new learning technologies. In A. Tait & R. Mills (Eds.), *The convergence of distance and conventional education: Patterns of flexibility for the individual learner* (pp. 100-109). London: Routledge.

Parker, R., Pettijohn, C. & Keillor, B. (1999). The nature and role of statistics in the business school curriculum. *Journal of Education for Business, 75* (1), 51-54.

Patrick, R. (1999). Not your usual maths course: Critical mathematics education for adults. *Higher Education Research & Development, 18* (1), 85-98.

Paul, R. (1990). *Open learning and open management: Leadership and integrity in distance education*. London: Kogan Page.

Peters, O. (1998). *Learning and teaching in distance education*. London: Kogan Page.

Petocz, P. (1998). Effective video-based resources for learning statistics. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 2, pp. 985-992). Singapore: International Association for Statistical Education.

Petracchi, H. (2000). Distance education: What do our students tell us? *Research on Social Work Practice, 10* (3), 362-376.

Pfannkuch, M. (1996). *Statistical interpretation of media reports*. Paper presented at the New Zealand Statistical Association 47th Annual Conference, Wellington.

Pfannkuch, M. & Brown, C. (1996). Building on and challenging students' intuitions about probability: Can we improve undergraduate learning? *Journal of Statistics Education, 4* (1). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v4n1/pfannkuch.html

Phillips, B, Francis, G. & Hutcheson, M. (1998). Statistics for workers in social and health sciences by flexible learning modes. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 1, pp. 401-407). Singapore: International Association for Statistical Education.

Pratt, D. (1993). Andragogy after twenty-five years. In S. Merriam (Ed.), *An update on adult learning theory* (pp. 15-24). San Francisco: Jossey-Bass.

Ramsden, P. (1992). *Learning to teach in higher education*. London: Routledge.

Reeves, T. & Reeves, P. (1997). Effective dimensions of interactive learning on the World Wide Web. In B. Kahn (Ed.), *Web-based instruction* (pp. 59-66). Englewood Cliffs, NJ: Educational Technology Publications.

Richardson, J. (1997). Dispelling some myths about mature students in higher education: Study skills, approaches to study and intellectual ability. In P. Sutherland (Ed.), *Adult learning: A reader* (pp. 166-173). London: Kogan-Page.

Roberts, D. (1996). Feedback on assignments. *Distance Education, 17* (1), 95-116.

Roberts, D. & Bilderback, E. (1980). Reliability and validity of a statistical attitude survey. *Educational and Psychological Measurement, 40*, 235-238.

Roberts, H.S. (1996). Should statistics be divorced from mathematics? *The New Zealand Mathematics Magazine, 33* (3), 17-19.

Rogers, A. (1993). Adult learning maps and the teaching process. *Studies in the Education of Adults, 25* (2), 199-220.

Roiter, K. & Petocz, P. (1996). Introductory statistics courses - A new way of thinking. *Journal of Statistics Education, 4* (2). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v4n2/roiter.html

Rossman, A. J. (1996). *Workshop statistics*. New York: Springer-Verlag.

Rossman, A. & Chance, B. (1999). Teaching the reasoning of statistical inference: A "top ten" list. *The College Mathematics Journal, 30* (2), 297-305.

Rumble, G. (2000). Student support in distance education in the 21st century: Learning from service management. *Distance Education, 21* (1), 219-235.

Sauve, L. (1993). What's behind the development of a course on the concept of distance education? In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 93-118). New York: Routledge.

Schau, C., Stevens, J., Dauphinee, T. & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes Towards Statistics. *Educational and Psychological Measurement, 55*, 868-875.

Scheaffer, R., Gnanadesikan, M., Watkins, A. & Witmer, J. (1996). *Activity-based statistics*. New York: Springer-Verlag.

Schuyten, G & Dekeyser, H. (1998). An electronic learning environment for applied statistics: Quality care and statistics education in higher education. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 2, pp. 711-716). Singapore: International Association for Statistical Education.

Seaton, W. (1993). Computer-mediated communication and student self-directed learning. *Open Learning, 8* (2), 49-54.

Sharma, S. (1996). The relationship between statistics and probability. *SAMEpapers 1996*, (pp. 93-110). Hamilton: Centre for Science and Mathematics Education Research, University of Waikato.

Simon, J.L. & Bruce, P. (1991). Resampling: A tool for everyday statistical work. *Chance: New Directions for Statistics and Computing, 4* (1), 22-32.

Simonson, M, Schlosser, C. & Hanson, D. (1999). Theory and distance education: A new discussion. *The American Journal of Distance Education, 13* (1), 60-75.

Simonson, M., Smaldino, S., Albright, M. & Zvacek, S. (2000). *Teaching and learning at a distance: Foundations of distance education.* Upper Saddle River, NJ: Prentice Hall.

Simpson, O. (2000). *Supporting students in open and distance learning.* London: Kogan Page.

Smith, P. & Dillon, C. (1999). Comparing distance learning and classroom learning: conceptual considerations. *The American Journal of Distance Education, 13* (2), 6-23.

Snee, R. (1993). What's missing in statistical education? *The American Statistician, 47* (2), 149-154.

Sowey, E. (1995). Teaching statistics: Making it memorable. *Journal of Statistics Education, 3* (2). Retrieved February 1, 2001, from http://www.amstat.org/publications/jse/v3n2/sowey.html

Sowey, E. (1998). Statistics teaching and the textbook - an uneasy alliance. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching Statistics, Vol. 1, pp. 151-158). Singapore: International Association for Statistical Education.

Stacey, E. (1999). Collaborative learning in an on-line environment. *Journal of Distance Education, 14* (2), 14-33.

Sutherland, P. (1997). The implications of research on approaches to learning for the teaching of adults. In P. Sutherland (Ed.), *Adult learning: A reader* (pp. 192-200). London: Kogan-Page.

Tait, A. (1995). Student support in open and distance learning. In F. Lockwood (Ed.), *Open and distance learning today* (pp. 232-241). London: Routledge.

Tait, A. (2000). Planning student support for open and distance learning. *Open Learning, 15* (3), 287-299.

Tanur, J.M. (1997). Discussion: Leading horses to water. *International Statistical Review, 65* (2), 159-161.

Taylor, P. (1996). Reflections on students' conceptions of learning and perceptions of learning environments. *Higher Education Research and Development, 15* (2), 223-237.

The Open Polytechnic of New Zealand. (2001). *Annual report, 2000.* Lower Hutt, NZ: The Open Polytechnic of New Zealand.

Thisted, R. & Velleman, P. (1992). Computers and modern statistics. In D. Hoaglin & D. Moore (Eds.), *Perspectives on contemporary statistics* (pp. 41-54). United States of America: Mathematical Association of America.

Tobias, S. (1993). *Overcoming math anxiety* (2nd edn.). New York: W.W. Norton.

Tolich, M. & Davidson, C. (1999). *Starting fieldwork: An introduction to qualitative research in New Zealand.* Auckland, New Zealand: Oxford University Press.

Townsend, M., Moore, D., Tuck, B., & Wilton, K. (1998). Self-concept and anxiety in university students studying social science statistics within a co-operative learning structure. *Educational Psychology, 18* (1), 41-54.

Valcke, M. (1998). Competency-based statistics courses with flexible learning materials. In L. Pereira-Mendoza et al. (Eds.), *Statistics – Expanding the network* (Proceedings of the Fifth International Conference on Teaching

Statistics, (Vol. 2, pp. 723-729). Singapore: International Association for Statistical Education.

Verduin, J.R. & Clark, T.A. (1991). *Distance education: The foundations of effective practice*. San Francisco: Jossey-Bass.

Vere-Jones, D. (1995). The coming of age of statistical education. *International Statistical Review, 63* (1), 3-23.

Watson, J. (2000). Statistics in context. *The Mathematics Teacher, 93* (1), 54-58.

Watts, D.G. (1991). Why is introductory statistics difficult to learn? And what can we do to make it easier? *The American Statistician, 45*, 290-291.

White, C. (1997). Effects of mode of study on foreign language teaching. *Distance Education, 18* (1), 178-196.

White, C. (1999). The metacognitive knowledge of distance learners. *Open Learning, 14* (3), 37-46.

Wild, C.J. (1994). On embracing the 'wider view' of statistics. *The American Statistician, 48* (2), 163-171.

Wild, C., Triggs, C., & Pfannkuch, M. (1997). Assessment on a budget: Using traditional methods imaginatively. In I. Gal & J. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 205-220). Amsterdam: IOS Press.

Williams, A. (1999). Novice students' conceptual knowledge of statistical hypothesis testing. In J. Truran. & K. Truran. (Eds.), *Making the difference* (Proceedings of the 22nd annual conference of the Mathematics Education Research Group of Australasia, pp. 554-560). Sydney, NSW: MERGA.

Willis, B. (Ed.). (1994). *Distance education: Strategies and tools*. New Jersey: Educational Technology Publications.

Wilson, J. (1998). Metacognition within mathematics: a new and practical multi-method approach. In C. Kanes, M. Goos & E. Warren (Eds.), *Teaching mathematics in new times* (Proceedings of the 21st annual conference of the Mathematics Education Research Group of Australasia, Vol. 2, pp. 693-700). Brisbane, QLD: MERGA.

Wise, S. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement, 45*, 401-405.

Young, G. & Marks-Maran, D. (1998). Using constructivism to develop a quality framework for learner support: A case study. *Open Learning, 13* (2), 30-37.

Appendices

Appendix 1: Questionnaire for beginning students

Learning statistics at a distance: Questionnaire for students of 72160

This questionnaire is designed to provide qualitative information from students of 72160. The objective is to find out the problems perceived by students when beginning a statistics course by distance education and the value they see in such a course. Please complete as many questions as possible.

1. Are you Male or Female? (circle one)

2. Have you done any distance education courses before? Yes No

   If yes, how many?.....

3. Have you done any statistics course before (at school or elsewhere)?

   Yes No

   If yes, please provide details.....

   .....

4. Write down some words to describe how you feel about beginning this course?

   .....

   .....

5. Can you explain what is causing you to feel this way?

   .....

   .....

   .....

6. How confident of success (i.e. completing and passing the course) are you?

   .....

7. You may be familiar with some of the problems of learning by distance education. Such things as trying to fit study in with your job or family responsibilities are common to all distance education courses. Do you anticipate that this course in statistics will present any difficulties for you over and above those common to all distance education courses? Describe any additional problems you anticipate.

.....

.....

.....

.....

8. How do you think you might deal with these problems?

.....

.....

.....

.....

9. What concepts do you think you will be introduced to in this course?

.....

.....

.....

10. What do you think is the value of having a compulsory statistics course in your degree?

.....

.....

.....

Thank you for your time and thoughts. Please return the questionnaire in the enclosed envelope by 2 March, 2001.

Appendix 2: Covering letter for beginning students' questionnaire

Dear

As you may know from your course materials and introductory letter, I am one of the three tutors for your course 72160, Statistical Analysis. To complete my thesis for a Master of Educational Studies (Mathematics), I am undertaking a study of the problems perceived and encountered when doing a statistics course by distance education and the value students see in such a course. This project is being done under the supervision of Dr Glenda Anthony, Department of Technology, Science and Mathematics Education, College of Education, Massey University.

This piece of qualitative educational research aims to record students' opinions, feelings and impressions by means of questionnaires and interviews. As a student in 72160 in the first semester, your opinions are very important to me.

Attached is a questionnaire which I hope you will complete to assist me in my work. The questions are open-ended, meaning that you can express any opinions you wish. **If there are questions you don't wish to answer, please leave them blank**. The questionnaire does not require a signature and there is no identifying code on it. Therefore your reply will be completely anonymous.

It is important to note that the questionnaire is entirely voluntary and completely independent of course work assessment. However, I do hope you will take the time to fill it in, as it is important I get a representative range of opinions. It is assumed that filling in the questionnaire implies consent for the use of this unidentified information in the preparation of my thesis and any subsequent papers or presentations relating to this project.

At the end of the semester I will be sending you another questionnaire, to see if your collective opinions have changed and to receive feedback on actual problems you encountered during the course. The two questionnaires will not be matched up as there is no identifying information on them.

Please send the completed questionnaire back in the envelope provided by 2 March, 2001.

The thesis is expected to be finished towards the end of the year. If you would like to be sent a summary of results, please let me know at the completion of your course. This research project has been reviewed and approved by the Massey University Human Ethics Committee, PN Protocol 00/146 and also has approval from the ethics committee at the Open Polytechnic of New Zealand. If you would like to discuss any issues arising from this research with my supervisor, Dr Glenda Anthony, she can be contacted at Massey University, phone (06) 350 69099 ext 8600.

Thank you for your co-operation.

Yours sincerely

Lois Curry
72160 tutor
[redacted]

Appendix 3: Questionnaire for completing students

Learning statistics at a distance: Questionnaire for students of 72160

This questionnaire is designed to provide qualitative information from students of 72160. The objective is to find out the problems encountered by students when completing a statistics course by distance education and the value they see in such a course. Please complete as many questions as possible.

1. Are you Male or Female? (please circle one)

2. Now that you have completed the course, write down some words to describe how you feel about learning statistics?

   .....

   .....

3. Can you explain why you feel this way?

   .....

   .....

   .....

4. Did you encounter any problems in the course over and above the usual problems of trying to juggle work and family responsibilities with your study?

   .....

   .....

   .....

   .....

5. What sorts of things helped in your learning?

   .....

   .....

   .....

   .....

6. What sorts of things made it difficult?

.....

.....

.....

.....

7. What additional types of support might have helped you cope?

.....

.....

.....

.....

8. Looking back on the course, what do you think are the most important ideas you will take away from this course?

.....

.....

.....

9. Can you explain why you gave this (these) idea(s)?

.....

.....

.....

10. How confident with using statistics do you now feel?

.....

.....

11. Do you think you will apply any of the things you have learnt in the course in the future? Please give examples.

.....

12. Did you use the set text during your course of study? Yes No

If so, how effective did you find it as a learning resource?.....

.....

13. Did you use the Telecourse Study Guide during your course of study?
Yes No

If so, how effective did you find it as a learning resource?.....

.....

14. Did you use the Against All Odds videos during your course of study?
Yes No

If so, how effective did you find them as a learning resource?.....

.....

15. Did you use the CD-Rom which came with the set text? Yes No

If so, how effective did you find it as a learning resource?.....

.....

16. Did you use the Media Activities Book which came with the set text?
Yes No

If so, how effective did you find it as a learning resource?.....

.....

17. Did you use the Tutorial and Revision notes? Yes No

If so, how effective did you find them as a learning resource?.....

.....

18. Did you use on on-line campus forum? Yes No

If so, how effective did you find it as a learning resource?.....

.....

Thank you once again for your time and thoughts. Please return the questionnaire in the enclosed envelope by 13 July, 2001.

Appendix 4 : Covering letter for completing students' questionnaire

Dear

You will recall that at the beginning of the semester you were sent a questionnaire to assist me with my thesis. To complete the picture I now need to know how you feel about learning statistics, what difficulties arose and how you coped with these.

So attached is another questionnaire. As before, please be frank and honest. **If there are any questions you don't wish to answer, please leave them blank**. It is assumed that filling in the questionnaire implies consent for the use of your unidentified information in the preparation of my thesis and any subsequent papers or presentations relating to this project.

As before, the questionnaire will be completely anonymous and contains no identifying code.

In addition to the information obtained from these questions, I am hoping to interview five students to obtain more in-depth information. If you think you may be able to help me with this, please also fill in the enclosed pink form and send it back to me in the second envelope. If you are one of the first five respondents with whom it is practical to arrange an interview, you will be sent an information sheet so you can make a final decision about participation. If you agree to participate, I will arrange a mutually agreeable time for a 30 minute interview. It is possible that not everyone who sends in an expression of interest will be sent the information sheet. This in no way reflects the importance I place on your comments but may simply be due to practical considerations.

The thesis is expected to be finished towards the end of the year. If you would like to be sent a summary of results, please contact me in about a month. This research project has been reviewed and approved by the Massey University Human Ethics Committee, PN Protocol 00/146 and also has approval from the ethics committee at the Open Polytechnic of New Zealand. If you would like to discuss any issues arising from this research with my supervisor, Dr Glenda Anthony, she can be contacted at Massey University, phone (06) 350 69099 ext 8600.

Please send your completed questionnaire back to me in the enclosed envelope by 13 July, 2001. Thank you once again for your help.

Yours sincerely

Lois Curry
72160 tutor, [redacted]

Appendix 5: Form for expressions of interest in interviews

Learning statistics at a distance: expression of interest in interview

Yes, I am interested in providing you with more in-depth comments. I agree to an information sheet being sent to me so I can make an informed decision about participation in the interview phase of this project.

Name:

Address:

Daytime phone number:

Please return this slip in one of the two envelopes provided. Please do not send it with your questionnaire, so anonymity of questionnaire responses is assured.

Appendix 6: Themes for semi-structured interviews

A. Learning statistics

Is learning statistics harder than learning other subjects? If yes, why do you think this is? What specifically makes it hard?

B. Learning statistics at a distance

What do you think are the differences between learning statistics at a distance and learning in a classroom environment? Do these differences make it harder to learn statistics at a distance? Why or why not?

C. Problems and strategies

What were the problems you thought you would encounter when you started this course? Did any of these eventuate?

If yes, how did you deal with them?

If no, why was this?

What problems which you hadn't anticipated were encountered?

Did you successfully deal with them?

What specific strategies did you use to overcome problems?

What advice would you give to students about to begin this course?

D. Support

What support from The Open Polytechnic staff did you find useful? What additional forms of support from The Open Polytechnic staff would you have found useful?

E. Value and concepts

What do you think statistics is all about? What are the main ideas?

What is the value of learning statistics?

Appendix 7: Information sheet for interviews

Learning statistics at a distance: Information for interview participants

As you already know, I am one of three tutors who teach the Open Polytechnic of New Zealand paper 72160, Statistical Analysis. You may also be aware that as part of my Master of Educational Studies (Mathematics) which I am completing through Massey University, I am writing a thesis concerning the ideas students have gained in their compulsory statistics paper, the difficulties they encountered when studying statistics by distance education and the strategies they used to deal with these difficulties. This piece of qualitative educational research aims to record students' opinions, feelings and impressions by means of questionnaires and interviews. As you indicated your willingness to provide more in-depth comments, I would like to invite you to participate in an interview.

During the interview, I will ask several open-ended questions. You should be aware of the following points.

- The interview will be audio-taped, but the tape recorder will be turned off at any time you request it.
- You are free to decline to answer any or all of these questions and may terminate the interview at any time you wish.
- If you answer a question and subsequently decide you do not wish your comments to be used, please let me know and I will delete the comments.
- The interview will take no longer than 30 minutes.
- You are free to ask questions about the research at any time before, during, or after the interview.
- You may request a summary of findings of the research.
- You are providing responses on the understanding that the following anonymity, confidentiality and security arrangements are adhered to.
- You will be asked to sign a consent form.

Confidentiality, anonymity and security

The interview will be audio-taped and later transcribed on to a recording sheet which will be identified by a code name only. No personal information, other than your gender and age-group will be noted. Your responses will not be discussed with any other person and your name will not be used in the write-up of the project. The tapes and recording sheets will be kept in a locked filing cabinet and will be destroyed once

the project is written up.

The information obtained will be used for the completion of my thesis and any subsequent research papers or conference presentations. Any direct quotations used will be identified by code name only.

If you have any questions, you are welcome to phone me or my thesis supervisor, Dr Glenda Anthony, College of Education, Massey University on 06 350 69099 ext 8600.

If, after having read this information sheet thoroughly, you are willing to participate, please sign one of the consent forms and return it to me in the envelope provided. The other copy is for you to keep. Once I have received a consent form, I will phone you to arrange a suitable time.

If you wish to have a friend or family member present while you are being interviewed, please feel free to invite them along.

Thank you for considering my request for an interview. I am confident that the information resulting from this project will be of benefit to those people designing and teaching statistics courses by distance education and therefore to future students.

Lois Curry
Mathematics and Statistics section
[redacted]

Appendix 8: Consent form

Consent Form

I have read the information sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction. I agree to participate in an interview with Lois Curry at a mutually agreeable time. I understand that

- I may ask further questions at any time
- The interview will be audio taped
- I may ask for the tape recorder to be turned off at any time during the interview
- My identity will not be disclosed in the report
- All responses will be kept confidential
- I have the right to decline to answer any questions and to terminate the interview at any time.
- If I ask for comments to be withdrawn, the researcher will comply.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed..... Date.....

Name.....

Yes, I wish to see a summary of the project findings.