## AMENDMENTS

**I. Comments on the use of the terms "Computer-Assisted Mathematics Learning" and "Distance Education" in the Title of the Thesis**

It has been suggested that the words "distance education" and "learning" should not appear in the title. These are not trivial issues. The following are therefore some comments on the reasons for the use of "learning" and "distance education" in the title providing some justification for their use.

a) Computer-Assisted Mathematics Learning.

It is to be noted that the use of computer terms and acronyms as used in the thesis is guided by the statements made in section 3.5 [pp. 86-87]. Here the point is made that the various terms and acronyms are often used interchangeably in much of literature. This applies particularly to computer-assisted instruction (CAI) and computer-assisted learning (CAL). The only obvious difference to be found in the literature is that American based literature predominantly uses the term computer-assisted instruction (CAI), as opposed to the literature in the field from Britain and the former colonies of Britain, which predominantly uses CAL. The approach and content described under the two titles CAL and CAI is frequently very much the same.
The use of Computer-assisted Mathematics Learning in the title of this thesis stems from these points. The review of the literature in this thesis notes the interchangeable nature of the acronyms CAI and CAL (p 87). Literature describing itself as "CAL" and "CAI" was reviewed as a whole in forming an overall view of the subject, without differentiating one from the other, because there was no basis for differentiating beyond the label used by the researcher(s) to describe the research.

In these circumstances there is no clear basis for asserting that one of CAL and CAI is more appropriate than the other as a label to be used for the research described in this thesis.

b) Distance Education

The justification for the use of the term distance education in the title stems from the fact that the research was conducted with students who are designated "distance education students" in PNG. Distance education, as administered by the Institute of Distance and Continuing Education (IDCE) at the University of Papua New Guinea, involves students who, in most subjects, attend a face-to-face component of the course of some 2 hours per week. This has been described in detail in the thesis. That is, the designation "distance education" is the usual way of describing UPNG students whose course structure is as it was for the students involved in this research (the usual distance mode plus some limited face-to-face contact through a study centre)

It is true that the same "experiment" could have been applied to "face-to-face", residential (designated "internal" in PNG) students. Internal mathematics students at UPNG attend some 6 hours of instruction in each course per week in the form of lectures and tutorials. This is not the case with distance education students at UPNG. The study reported in this thesis looks at how the 2 hours per week contact time component of the mathematics course for distance students can be better utilised to achieve optimum learning in the said course. This was done in the context of the observed problems faced by PNG distance education students.

Therefore, while the study is not a significant contribution to the conventional/theoretical description of distance education per se (that is a mode where there is no face-to-face contact), it does focus on distance education practice in PNG and therefore the inclusion of the term "distance education" in the title is justified.

**II. Comments on Conclusions and Recommendations**

1. The conclusion in section 7.9 page 262, paragraph 2, line1, which reads "the largely positive results...", might be interpreted to be overstating the findings somewhat, but this is not the case because of the following. The statement was made in the context of the position argued elsewhere in the thesis that a no significant difference result in the comparative performances of the CAI and TM students can reasonably be seen as a positive result for the study (see pp 258). In other words CAI is as good as TM. The results basically show that CAI is not inferior to TM but was equal in effectiveness to TM for the study population, a population that had previously consistently performed at lower levels than TM groups. These issues are fully described at various points in chapter 4 and 5.

2. The possibilities of a Hawthorne effect impacting on the study were not ignored; conclusions stemming from the study took this possibility into account. The reader is therefore advised to keep this in mind whilst noting the conclusions from the study.

3. While it is true that the study was not conducted at a University Centre per se, but at the Main Campus of UPNG, the mode of application of any CAI program developed and accepted for use in distance education in PNG would be along similar lines to that in the study.

4. While computer resources are generally scarce in PNG there is an increasing sense of the importance of computers in work and education and an increasing number of Papua New Guineans are investing in home computer equipment. Given the factors impacting on education, distance or otherwise, in PNG, no teaching method, however common, is going to reach every Papua New Guinean anyway.

5. It should be further noted that two University Open Campuses, formerly University Centres, now (August 2002) have computer laboratories. This is within less than 7 months since this thesis was concluded. IDCE is in fact continuing to develop this 'super' University Centre concept in which it is planned that all four Open Campuses currently in operation will have at least one computer laboratory each with networking capacity. This shows that it is not impossible to provide computers at selected centres to implement the recommendations by the researcher stemming from the study. The problems associated with installing computer laboratories are indeed numerous, and Papua New Guineans are painfully aware of this. The impression therefore that the recommendations stemming from the present study as regards the establishment of computer laboratories in selected centres in the country are utopian is unnecessarily pessimistic.

6. A final point that can be made in regards to the introduction of computer technology to work and education in PNG is that it is very rapid and compares well to technologically advanced countries such as Australia.

7. Although the recommendations made in the present study were focussed on mathematics it was never ever envisioned that computer laboratories would be set up solely to teach just one 'pre-university curriculum area'. It is not reasonable to conclude this about the recommendations of the study. Computer laboratories are being set up to provide distance education services, and

mathematics is just one area of learning that will make use of these facilities. These recommendations were made with some inside knowledge of plans for the use of computer technology in delivering distance education in PNG.

8. On pages 209-210, table 6.1, the test-retest reliability correlation between the pretest and the posttest of 0.528 is incorrectly described as "high". On advice the researcher now recognises that this correlation level is not high at all amongst research instruments of this kind, even though it is statistically significant.

## III Other comments

1. The reference to "intervening years" on page 5 (mid page) refers to the years since distance courses were offered through extension studies at UPNG which is from the late seventies to the present.

2. On Page 10, last paragraph, the sentence beginning "Up to 1989..." should read "Up to 1985..."

3. On page 33 effect number 1 refers to the re-organisation of the levels of general education in PNG. The first 3 years (k-2) is now called elementary school. Primary school now goes from grade 3 to grade 8 whereas it used to go from grade 1 to grade 6. High school or secondary school now goes from grade 9 to grade 12 whereas it used to go from grade 7 to grade 12.

4. On page 63, section 2.12.5, last line, first paragraph, the phrase "...educational goals that are more modest" is a statement of comparison of the educational goals in PNG with those from other more technically advanced countries.

5. In table 5.1, page 169 (reproduced below) all the percentages should be read with "about" in front of them because these were all rounded off (see table below). Additions to the table are underlined.

**Table 5.1: A Comparison of Sample Population Characteristics between the Pilot Study and the Main Study.**

| Pilot Study (semester 2, 1999 cohort) | Main Study (semester 1, 2000 cohort) |
|---|---|
| • About 75% of the sample was in the 18-24 years age group | • About 71% of the sample was in the 18-24 years age group |
| • About 81% of the sample was male | • About 74% of the sample was male |
| • About 81% of the sample had enrolled in the Adult Matriculation program after completing grade 10 only | • About 81% of the sample had enrolled in the Adult Matriculation program after completing grade 10 only |
| • About 32% of the sample had attended some form of tertiary education | • About 36% of the sample had attended some form of tertiary education |
| • About 30% of the sample were repeating the course mathematics 2 | • About 33% of the sample were repeating the course mathematics 2 |
| • At least 30% of the sample listed a trade or occupation. | • At least 31% of the sample listed a trade or occupation. |
| • About 32% of the sample were employed | • About 29% of the sample were employed |

## IV Editorial matters

- p 5 line 7: "than the written materials", not then
- p 9, 4th last line: should read " ... alternative ways of expanding educational opportunities."
- p 11: "ones" should be "one's"
- p 54, first line after diagram: "*" refers to section 2.2.1.1
- p 193, line 11: "CSQ1" should be "CSQ2"
- p 194, section 6.3.1 para 2 line 1: Appendix 8, not Appendix 5

References:

- p 10: Young (1980) should be "Young, Perraton, Jenkins and Dodd (1980)"
- p 25: Conroy, 1979 should be "Conroy & Skeldon, 1979"
- p 51: Young 1998 should be "Young & Marks-Maran, 1998"
- p 57: Holtzmann (1975) should be "Holtzmann, Diaz-Guerrero and Swartz (1975)"
- p 58: Guy (1989) should be Guy (1990)
- p 72: Berge should be Burge
- p 73: Berge should be Burge
- p 110: Fitzgerald, 1996 should be Fitzgerald & Koury, 1996
- p 113: Thomas (1997) is NOT in reference list
- p 233: Holtzmann, 1975 should be Holtzmann et al., 1975
- p 249: Lauzon, 1989 should be Lauzon & Moore, 1989

A number of quotes in the text of the thesis do not have the relevant page number(s) for the cited material. These are:

- p 13: quote from UNDP is from p 1 of that publication
- p 50: quote from Hackbarth is from p 16 of that publication
- p 51: quote from Greening is from p 24 of that publication
- p 52: quote from Arger is from p 9 of that publication
- p 54: quote from Markowitz is from p 1 of that publication
- P 56: quote from Guthrie is from p 189 of that publication
- p 56: quote from Van Trease is from p 11 of that publication
- p 57: quote from Guy is from p 205 of that publication
- p 82: quote from Campion is from p 186 of that publication

# Computer Assisted Mathematics Learning in Distance Education in Papua New Guinea

by

McClintock Jesse Dandava

MSc (Reading), BSc (UPNG), DST (Fulton)

A Thesis submitted in fulfilment of the Requirements for the degree of Doctor of Philosophy, Faculty of Education, Monash University

December 2001

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## Abstract

Computer-based teaching and learning systems have become ubiquitous to many facets of life in the modern world including education in recent years. Its association with distance education in particular is powerful and is the subject of much discussion amongst distance education practitioners. The powerful link to distance education is due to its potential to bridge the 'time' and 'distance' gap between the instructor and the student that is inherent to distance education. Many developing countries in particular see distance education as the only viable option left to solving the problem of access to education particularly at the tertiary level. Faced with a booming population and the consequential shortage of tertiary spaces, Papua New Guinea (PNG) has also strongly advocated a distance-based, computer technology-mediated expansion of educational opportunities.

The present study, in rising to the challenge, investigates the teaching of a distance education mathematics course using computer-assisted instruction (CAI) at the Institute of Distance and Continuing Education in the University of Papua New Guinea. The study sought to explore the viability and the applicability of a computer-assisted instruction mode of teaching and learning in a mathematics course in comparison to the traditional text and face-to-face modes.

The findings in the study suggest that a computer-assisted instruction mode of teaching and learning mathematics in PNG is viable and can be effective. Students in a CAI tutorial group performed as well as students who did the course through the traditional methods in a mathematics achievement test.

The study has important implications for the adoption and implementation of computer-based learning systems in PNG especially in distance education.

## Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university, and, to the best of my knowledge and belief, contain no material previously published or written by any another person except where due acknowledgement is made in the text.

Signed: [redacted]

McClintock Jesse Dandava

Date: 28/11/2001

This research project was approved by the Standing Committee on Ethics in Research on Humans of Monash University on 8 February 2000 (Project 2000/010).

## Acknowledgements

I would like to extend my deep gratitude to both of my supervisors, Professor Richard F. Gunstone and Dr Graham W. Dettrick for their guidance and support throughout the period of my study. Dr Dettrick as my beginning principal supervisor, for providing the early direction in the study for a raw, direction-less research student and Professor Gunstone for taking over as principal supervisor in the latter half of my study and guiding me through to the end. I wish to also thank the staff and the research students at the Faculty of Education at Monash for providing the necessary support in fulfilling the requirements of this thesis.

I am also grateful to the Australian Government for making it possible for me to study at Monash University by providing a scholarship through AusAID to finance my study. I would also like to thank the University of Papua New Guinea (UPNG) for granting me study leave and maintaining financial support to me and my family right through the entire period of the study.

I am indebted to the students who made the study possible by being the subjects in my study as well as colleagues at UPNG who helped me in one way or another. In particular I acknowledge the support and help provided by the staff of the Institute of Distance and Continuing Education (IDCE) at UPNG in facilitating my fieldwork. I particularly would like to acknowledge the help and support of the mathematics coordinator, Dr Francis Kari, who went out of his way to facilitate my research fieldwork involving his area of responsibility and students.

I also thank Dr Wilfred Kaleva and others for their invaluable assistance in helping me settle quickly into my study here. I am also grateful for the friendship of Leongatha SDA church members and other friends in Victoria for making our stay in Australia fruitful and enjoyable.

Finally and most importantly I would not have done this without the full support of my beloved wife, Cherolyn and children, Lorel, Sasha and Tio, who suffered through the four years with me writing this thesis, my dad, Togholo Oussie, and brother David and family including Oliver and Orlando and late brother Solomon.

To you my family, including members who have gone and will not help me celebrate this achievement, I dedicate this thesis.

# Chapter 1: Introduction

## 1.1 Introduction

The idea for this research was born from a desire to improve the instructional and learning practices of the Institute of Distance and Continuing Education (IDCE) at the University of Papua New Guinea (UPNG), particularly in the area of mathematics. It stems from the experiences of the researcher, as a former mathematics coordinator for IDCE. The direction the study takes taps into the interests of the researcher into computer-based instruction and learning systems in mathematics. It is motivated by a belief that a move in this direction may better facilitate a cost-effective, efficient, more student-centred, flexible and interactive learning environment at a distance. A learning environment that reflects, engenders, encapsulates and embraces a more constructivist outlook in the provision of educational instruction, in distance education in PNG. It is also recognition of the limitation of text only tuition, which up to now has been the main media of instruction available, aside from very limited face-to-face (FTF) instruction which is often not even provided in many cases.

The recent advances and proliferation in computer-based educational technologies have provided the impetus to undertake a study such as this in the Papua New Guinea (PNG) context. Before 1997, the direction taken by the present study in the PNG context would not have been feasible.

Some observations of IDCE students suggest that they prefer face-to-face (FTF) instruction to text-based instruction, although there is no empirical data to support this. A study by Kaeley (1989) at UPNG, although not comparing the variable of preference for tutorial modes by distance students, does indicate that there is a significant association between tutor helpfulness and mathematics achievement. Markowitz (1994) noted that the lack of physical presence of a human instructor in the distance education mode poses a problem for PNG distance students. Distance education has also suffered an image problem in Papua New Guinea being seen as not quite equal to classroom-based FTF instruction and learning (Markowitz, 1994).

Despite these problems in perception of distance education in PNG, the concerted push recently towards adopting a computer-based distance education teaching and learning paradigm makes such a reality a given. The driving force behind this push is the real problem of access to higher education being experienced in the country.

This study addresses some of the concerns of the lack of 'presence' in the distance mode of study, using computer-based educational technologies. It is also a response to the push towards a computer-based distance mode of access to higher education in PNG.

## 1.2 The Research in Perspective

Recent advances in computer technology in particular have made it increasingly possible to better target individual learner needs than ever before. Many distance education courses in many countries are increasingly being made available online or mediated by some form of computer-based technology such as CD-ROM in one way or another. In fact, computer mediated communications (CMC) are rapidly moving towards blurring the distinction between face-to-face education and distance education that some exponents of the latter have tried to create by various definitions they have proposed. For instance, the notion of ***separation of instructor and student by time and space*** that is so essential to defining distance education as distinct from education, is being increasingly challenged by the rapidly improving educational technologies outlook.

Due to the realities of the general lack of computer access to many Papua New Guinean students, it is not feasible at present to investigate some aspects of the current state of CMC in the PNG context. Included in this category for the present at least is online learning in general, although this is rapidly becoming feasible to a limited extent.

However, it is feasible to investigate the aspects of CMC that pertain to and are facilitated by multimedia CD-ROMs and other newly introduced devices of similar function to the CD-ROM. The present study in fact uses CD-ROM and CD-

ROM-like devices such as the zip drive as the enabling technology to facilitate the investigation.

It is the desire of the researcher to anchor the introduction of this new teaching and learning media on a soundly researched basis, as opposed to an ad hoc basis driven by nothing more substantial than general impressions. The research approach adopted in the present study is designed to avoid the pitfalls of the haphazard introduction of new learning technologies, which could result in the introduction of expensive but ineffective computer-based systems of teaching and learning.

Research is vital to investigate the impact of computer-based instructional models on student learning in the PNG context. This would ensure that the impact on students' learning is significant for the time, effort and cost expended in introducing them as alternative teaching and learning modes. Research would also determine whether this impact is positive or negative.

It is well to note the words of caution by Bates (1990), that:

> The history of education, particularly in developing countries, is littered with the corpses of technology-based projects that were killed off because of the high operating costs, problems of adaptation to local conditions, lack of skilled personnel to operate the technologies, and lack of effectiveness. (Bates, 1990)

Keeping this warning in mind, the scope of the study, in terms of the adoption of appropriate technology, is limited to what can be sustained in terms of the technology that is available to the target population. Computer laboratories are available at the University of Papua New Guinea and the study is designed to adopt a computer laboratory-based application.

This study is therefore an outcome of the understanding that research is vital in understanding how computer-based learning systems impact on students' learning. In this study the impact of a computer-based instructional model in a distance education course at UPNG is investigated.

## 1.3 The Problem Stated

The provision of distance and continuing education services by IDCE has faced many challenges over the years the program has been in existence. Many of these challenges remain unresolved up to the present time. In a developing country like Papua New Guinea (PNG), where resources are scarce, it is not easy to address these challenges. There are continuing problems that IDCE must address in providing the distance and continuing education program. The following paragraphs note some of these problems or challenges.

Some of the more obvious problems include the cost-effective and timely production of written materials and the delivery of the written materials to the University Centres. (For a brief description of the system of University Centres of UPNG, see chapter 2, figure 2.1 and section 2.12.3). Production of materials has always been a problem due to various logistic reasons, not the least of which are inefficient production systems. The delivery is often through airfreight cargo services, which are expensive.

There are also problems in the provision of tutorial services, outside of the bigger centres in PNG. In mathematics in particular but also in other subject areas often it is not easy to find qualified staff in the more remote areas of the country. Even where qualified teaching staff are identified student concentration in terms of numbers often make the staging of tutorials uneconomical and cost-inefficient.

Instituting timely updates to written materials to keep them abreast of the state of development in the relevant fields of study at all times is also a continuing problem. This is a particularly critical problem as a large number of the courses offered by IDCE are in dire need of substantial updating, particularly in the area of mathematics. At present the process of updating courses takes an inordinately long time and severely drains limited human resources in IDCE.

The prevailing education philosophy behind the design and delivery of IDCE course materials still derives from the now largely abandoned behaviourist notions of education. A conscious effort to engender constructivist notions of learning is imperative.

The list of problems noted is by no means exhaustive. There are other problems of varying degrees of severity.

Since the inception of the Extension Studies Department, the courses on offer through the distance mode have all been text-based, supplemented with very limited FTF tutorials. Experience over the years has shown that an increasing number of the students are more dependent on the limited amount of FTF instruction to keep them focussed on the course, then the written materials. This is evidenced by the fact that regardless of the non-compulsory nature of the tutorial sessions, the sessions are well attended. Even when the students are repeatedly made aware that the tutorial sessions only review what is already presented in the written materials, they still prefer, where possible, to attend FTF tutorial sessions. Some theoretical considerations for the possible reasons for this preference for FTF contact with the instructor are discussed in chapter 2 in the section on pedagogical and cultural issues (section 2.11.3).

Regardless of this obvious preference for FTF tutorial sessions there have been no moves in IDCE to address the situation in terms of a modification in the mode of course delivery over the intervening years. There has been a marked resistance in IDCE in fact to the pressure from the students to increase FTF tutorial contact time from the current 2 hours per week contact time per student per course.

In fact the general thinking has been to do away with the FTF tutorials altogether. There are two main reasons for this. The first is because of the extra administrative load the mounting of the FTF tutorials imposes on the Institute's comparatively small staff. The other is the general view prevalent amongst distance education practitioners that the provision of FTF tutorials somewhat defeats the whole purpose of what constitutes distance education. Regularly scheduled tutorials for distance education courses, as is the case at UPNG, make the distance education courses no different from classroom-based FTF tutorials other than that the tutorials are less frequent (one tutorial per week).

The present study was an attempt therefore by the researcher to address the problems noted above that IDCE faces, taking into account the students' preferences for FTF tutorials in doing distance education courses offered by IDCE. The courses of particular interest to the present study were the mathematics courses offered by IDCE. The direction the present study takes in offering a solution to at least one of the problems noted is through the application of computer-based methods of instruction.

In the light of the more recent emergence of computer-based methods of instruction, the researcher aimed to address at least the problem of the provision of limited FTF tutorial instruction. The question was whether it was possible through computer-based methods to simulate a FTF tutorial situation that is as effective at the very least as a FTF tutorial situation. The challenge was to achieve this without an over-reliance on the presence of a human tutor although the importance of human presence was not totally diminished.

Recent advances in computer technology have made it increasingly possible to target individual learner needs better than ever before. There is an increasing volume of literature on studies on the efficacy of computer-based methods of instructions compared to other more traditional methods of instruction. Chapter 3 on literature review highlights some of these studies. Distance education courses in many countries are increasingly being made available online or mediated by some form of computer-based technology such as CD-ROM for instance.

In the light of advances in computer-based learning technologies, there was the opportunity to investigate alternative means of provision of distance education services at UPNG to address at least one aspect of the perceived problems.

## 1.4 Purpose and Significance of the Research

The overarching aim of the present study was to investigate the efficacy of a computer-based method of mathematics instructions, in providing the limited FTF tutorial assistance to distance education students at UPNG. The specific aim was to investigate whether CAI is less effective, as effective or more effective than the more traditional modes of instruction, in particular, the limited FTF instruction often provided, where feasible, to distance education students in the UPNG distance education program. The emphasis was more on determining whether CAI can be as effective as the usual practices, termed "traditional methods" (TM) in the present study, in teaching and learning in distance education.

The purpose as stated is not an argument against the more traditional modes of instruction, such as the FTF mode of instruction, per se. Rather the purpose is to investigate the use of computer-based instruction modes to complement, supplement, extend or enhance existing practices. Even where it is necessary to have human presence, to utilise the human resources more efficiently and effectively.

The significance of the study derives from a concerted drive in the last two years in PNG to adopt a distance learning paradigm mediated by computer-based educational technologies. This concerted drive has been motivated in the main by the inadequacy of 'traditional' education facilities to cater for all eligible stakeholders particularly at the tertiary level. The situation of inadequacy has become more acute with the unexpected population surge in the decade to year 2000.

The desirability of a computer-based distance education push is imperative in relation to tertiary level education. The Universities in PNG in particular have a keen interest in this mode of education because very little funding for expansion of facilities is foreseeable in the near future. The only way forward for tertiary education therefore to make available their courses to the wider community is by computer-based distance education.

While the voices urging this change in educational direction are getting louder and more urgent, the research-based response to this has hardly begun. In the area of computer-based learning systems, especially in distance education in the PNG context, the present study is one of the very few such studies at present. There is therefore no problem in establishing the importance of a study such as this in the PNG context.

It is the purpose of the present study to take a few tentative steps towards investigating the efficacy of computer-based instruction and learning systems.

## 1.5 Anticipated outcomes

What will happen as a result of this study?

The study has important implications for evaluating computer-based learning systems in the distance education context. The results will be used to guide decision-making in responding to calls urging the adoption of computer-based distance education in expanding educational opportunities for Papua New Guineans especially at the tertiary level. It will also form a basis for the development or the adoption and modifications of interactive computer software for use to provide instructions to distance students and independent learners. Given the pioneering nature of the present study, the researcher hopes to lay some groundwork for studies of this nature and in this field in the future. It aims to identify some of the problems in research such as this and fruitful directions for further research in this field in the future.

## 1.6 Rationale and Justification for the Present Study

This section provides the rationale for the present study in a general context (section 1.7.1), the PNG context (section 1.7.2) and a CMC context (section 1.7.3).

### 1.6.1 General Rationale

Most, if not all governments in the world, readily espouse the social ideal as embodied in the catch cry, *education for all* when it comes to the education of its citizens.

Since independence in 1975, successive governments in Papua New Guinea have tried in various ways to achieve this ideal. One only has to look at the numerous five-year plans in education that have been proposed and implemented since 1975 (e.g. Conroy and Skeldon (1979)) to get an idea of the efforts that have been made. Actions taken to achieve this ideal have resulted in a whole range of effects (Turner, 1990), not all of which were desirable, intended or even effective for all the efforts expended.

In an article for the World Bank Report Sharma (1987: p. 45) proposed a major reason for the popularity of the ideal of *education for all* by many governments. He proposed that " development starts with people, their education and their capabilities because people are the primary and ultimate focus of all development (...)". He developed this view further in stating that "education is not only a social and moral imperative, it is also an economic necessity".

More to the point, Evans (1991) proposed that development in developing nations is dependent on boosting the education levels of the population alongside developments in other important areas of society.

The International Bureau of Education, in a research project on educational goals and theories in the late seventies, came up with statements on the goals of education as seen by nations in various regions in the world. These were nation-building, the fostering of national identity, creating a new man as opposed to a revitalised traditional man and education as a tool for increasing social participation (Burns, 1987).

Bringing these varied views of the role of education into focus in the PNG context, Weeden, Beeby and Gris (1969), in a report on education in Papua New Guinea to the Australian Minister of Territories, observed that:

> It is only within quite recent years that, in countries like Papua New Guinea, full weight has been given to another purpose in education; without education such countries have no hope of achieving the independence, the economic growth, and the higher standards of living on which they have set their hearts.

In a recent graduation speech, the current Prime Minister of PNG, Sir Mekere Morauta, stated that education is the cornerstone of national advancement. He was speaking in the context of understanding and effectively utilising the technological and information revolution that the computer age has thrust upon the nation. It was his conviction that education is critical to understanding the technological and information revolution (Web Society, 2000). Various interest groups within PNG have repeatedly highlighted the critical nature of education to facilitate the effective use of computer technology and the information revolution.

While the national will and desire to provide universal education for all is evident, there are entrenched factors that militate against this will and desire. A major factor is the alarming growth rate in the national populations in most developing countries, which are stretching to breaking point the limited national resources (Selim, 1986), coupled with the general downturn in economic performances.

It was within the framework of the national desire to achieve the ideal of *education for all*, constrained by limited national resources, that educational planners in developing countries such as PNG started to look for alternative ways of educational opportunities. The alternative ways included a serious look at distance education.

Many governments are attracted to distance education because it is seen as a relatively cheap means of expanding educational opportunities and improving access to education for the people (Markowitz, 1993). In answer to the question, why distance education, Selim (1986) stated that distance education showed that it could provide educational opportunities to large numbers relatively cheaply. Distance education appears, on the surface at least, a relatively cheap alternative that is generally free from the constraints imposed by the traditional 'four-walls, face-to-face' mode, which is not accessible to all.

The alternative mode had to fulfil the criteria that it must reach those members of society who for one reason or another have not been able to participate in traditional education or attend educational institutions (Bank, 1986). Included in this group were many women who were homemakers who could not leave home to return to fulltime studies. Also included were many people who were employed fulltime and who could not afford the time to return to fulltime studies. Most importantly, in the PNG context, the group largely consists of those who are unable to find places in conventional institutions because of inadequate educational facilities.

Young (1980) cites Julius Nyerere as stating that " education has to increase men's physical and mental freedom to increase their control over themselves, their own lives, and the environment in which they live …".

It is therefore not difficult to see why governments in developing nations such as PNG see educational provision as essential despite the limited resources.

### 1.6.2 Justification in the PNG Context

While it is obvious that the intention has been there to provide more educational opportunities, due to the limited educational resources, the percentage of school-aged children who find places in the schools in Papua New Guinea is still very low. The following statistics from a Department of Education (DOE) publication (1985) bears this fact out glaringly. Up to 1989, only 71% of the population age group attended primary schools (grades 1 – 6), 18% of the population age group attended provincial high schools (grades 7 – 10) and 2% attended national high schools (grades 11 & 12). Only 0.5 % of the population age group attended universities.

Embedded in these statistics and concealed within the general figures was the even lower participation rates of the female members of the population age groups (Dandava, 1987).

The current PNG Minister of Education recently revealed that according to a study concluded recently up to 2 million children who are of school age are not in classrooms. This is despite the fact that the education reform has increased education access for school-aged children from 300,000 to 500,000 (Missing School, 2001). This figure of 2 million has now been revised upwards to 2.75 million (Education Failing, 2001; No Access, 2001) since the release of the Census 2000 results.

In the face of the dismal statistical commentary that the foregoing figures present, it is not difficult to justify the necessity of a study such as this. The present study is another chapter in the continuing attempts to explore every possibility in the quest for increased, quality educational access and opportunities for Papua New Guineans. The investigation in the present study is even more imperative now with the increasing use of computer-based technologies, the new media that have shown a vast potential to reach greater proportions of students. The investigation presented in the present study is a research-based response to the calls within PNG for a more concerted effort to adopt computer-based technologies to address the perceived educational needs of the people of PNG.

To ignore the use of computer-based technologies in addressing perceived educational needs, which is the focus of the present study, for whatever reason is tantamount to 'sticking ones head in the sand'. Bates (1994) highlights this when he states that "technology change is now becoming so pervasive that educational institutions ignore it at their own peril".

The present study is therefore concerned with investigating the case for the facilitation of distance teaching and learning in Papua New Guinea through Computer-assisted Instruction (CAI) an aspect of CMC. It attempts to focus attention on this relatively new area of research into educational access thereby opening a whole new vista of educational opportunities in PNG.

The present study is aiming to examine the pedagogical pertinence, in the Papua New Guinea cultural context, of adopting the CAI aspect of CMC in delivering distance education, specifically in the area of mathematics.

### 1.6.3 Justifying the use of CMC

CMC use occurs in both the FTF and distance education modes of education, but it is in the latter field that it promises the greatest impact. Kaye (1989) in commenting on CMC states that "the educational potential of such computer-mediated interactivity, and the open-ness to multiple discourse and perspectives, which it can permit, is enormous". CMC combined recent advances in telecommunications with computer capabilities providing methods of interacting educationally at a distance that are unique (Garrison, 1993).

Most major studies on the use of CMC in the delivery of distance education courses occur in the industrialised nations rather then in the developing ones. The present study therefore is without precedent in the context of Papua New Guinea at the very least. The study aims to compare the learning outcomes of students taught via CAI, an aspect of CMC, as opposed to the learning outcomes from the usual methods of teaching and learning.

The usual methods, which in the context of the present study are referred to as traditional methods (TM), involve distributed printed course materials used as the main media of teaching and learning. This might include a limited amount of supplementary FTF tutorials where tutors are available and it is cost-effective to provide them.

The rapid growth in the development of technology for CMC has pushed the field of distance education into a potentially new plane of operation. This has been further boosted by the prominence given to internet-based, education which has resulted in more and more 'traditional' educational institutions as well as other educational institutions going online every year especially in the developed world.

The introduction of computers and computer-based instructional technologies such as the Internet or the world wide web, Computer-assisted Instruction (CAI) and other forms of computer-based media have opened up new possibilities for distance education. It is now increasingly possible for teaching and learning to occur in real time and at a near FTF level at a distance without the tyranny imposed on traditional models of distance education by time and space.

Papua New Guinea as a developing country with limited financial resources cannot emulate the industrialised countries in the level of development in computer-based distance education. It is important to recognize however, that studies such as this can help in directing efforts to better utilise the aspects of computer-based teaching and learning that are available and will become available in the near future.

The UNDP (2001) concurs with this point of view in making the point that:

> The technology divide does not have to follow the income divide. Throughout history, technology has been a powerful tool for human development and poverty reduction.

More recently, the use of computer technology has become more prevalent in business and education in Papua New Guinea. The theme of the present study is therefore not misplaced or ahead of time. In fact, judging from the pronouncements and public statements in the print media in PNG recently, there has been a noticeable increase in rhetoric from the government about the pressing need to adopt computer and internet-based means of educational provision. This is particularly the case in the context of distance education.

The PNG Minister of Education, Dr Waiko, in a recent article in the Post Courier (New Direction, 2000), was quoted as saying:

> It is time to bid farewell to campus-based education and the teacher-student and classroom system. We have to move to a student-computer-distant learning system now"

He said that his vision was to have students living at home in any part of PNG doing tertiary courses on-line. He has repeatedly highlighted this vision in various forums around the country. He has also urged education administrators and planners to stop thinking of hi-tech delivery of education as a future vision. Referring to 'hi-tech' delivery of education, he urged that "they have to harness and embrace it for the cost-effective delivery of both basic and higher education in Papua New Guinea" (Go hi-tech, 2001).

Various leaders, including the Prime Minister, have repeatedly echoed these sentiments in recent months (Education Key, 2000; Web Society, 2000). The recently passed Higher Education Plan (2000 – 2004) formalised these sentiments in placing a pronounced emphasis on distance and flexible learning through the electronic media to increase access to Higher Education in the country (Higher Education, 2001; Tertiary Education, 2001).

The voices in PNG urging the adoption of computer-based means of providing educational opportunities that are both flexible and at a distance are becoming more strident. There is therefore the national will and desire to go down the part of appropriate computer technology in providing flexible learning at a distance, the lack of appropriate resources notwithstanding.

Like many institutions in other countries, UPNG has recently taken its first major step towards adopting a computer-based learning paradigm in its programs through the commissioning of an internal fibre-optic network and the www on its Main Campus, in 1997. There is potential for the provision of Distance Education services at UPNG to become available like never before on the back of these new computer-based learning technologies.

The next section presents the research questions listed according to the three directions in which the present study is organised and implemented. The research hypotheses are reported where appropriate in chapter 4 for the pilot study and chapter 6 for the main study. The three categories or directions of the study are attitudes to mathematics, attitudes to computers and performance in mathematics as a function of instructional mode. While the main thrust of the present study is comparative performances of students in a mathematics course, consequential to mode of instruction, the two attitude questionnaire instruments investigate the context in which the student performances are recorded.

## 1.7 Research Questions

The three main directions that this research takes in generating the investigation questions are students' attitudes to mathematics, students' attitudes to computers and change in student performances in a pre-university, mathematics achievement test.

### 1.7.1 Mathematics

The attitudes of PNG distance education students, towards pre-University mathematics, provide an attitudinal context to their performances in the achievement test.

1. Do matriculation level students in PNG enrolled via the distance study mode in mathematics, in general, have positive or negative attitudes towards mathematics?
2. Do matriculation level students in PNG enrolled via the distance study mode in mathematics see mathematics as too difficult?
3. Is there a significant difference in attitude between the CAI and TM students to the relevance of mathematics to their cultural context?
4. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is confusing?
5. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is important?
6. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is useful?

### 1.7.2 Computers and CAI

The following questions guided the investigation of the students' attitudes to computers and CAI software.

1. Do PNG distance education matriculation students have positive or negative attitudes towards the use of computers for learning?
2. Do PNG distance education matriculation students have positive or negative attitudes towards the introduction of CAI to the teaching of pre-university mathematics?
3. Do PNG distance education, matriculation students see CAI as an effective medium of mathematics instruction to distance students?
4. Does exposure to CAI improve the level of motivation and interest in mathematics in the students?

5. Do PNG matriculation students enrolled through the distance mode see the situation where the student is able to learn at his or her own pace as a desirable outcome?
6. Do PNG matriculation students enrolled through the distance mode see the situation of reduced dependence on a human tutor as a desirable outcome?

### 1.7.3 Mathematics Achievement Tests - Pretest, Posttest and Final Examination

#### 1.7.3.1 Difference in Performance over time (Pretest-Posttest)

1. Is there a significant difference in the students' level of competence in mathematics 2 concepts between the results in the pretest and the results in the posttest?

#### 1.7.3.2 Pretest

1. Is there a significant difference in performance between the CAI group and the TM group in the pretest?

#### 1.7.3.3 Posttest

1. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least one session?
2. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least two sessions?
3. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least three sessions?
4. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least four sessions?

5. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least five sessions?
6. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least 6 or 7 sessions?

#### 1.7.3.4 Final Examination

1. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least one session?
2. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least two sessions?
3. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least three sessions?
4. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least four sessions?
5. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least five sessions?
6. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least six or seven sessions?

## 1.8 Structure of the Thesis

The remainder of the thesis is structured as follows:

Chapter 2 consists of two main sections representing two of the three different settings for the study: a PNG setting and a distance education setting. The PNG section described some relevant and important features of the country together with an educational map, both historical and current to contextualise the problem. The section on distance education presents a developmental perspective of distance education as a field of research and distance education development in PNG.

Chapter 3 presents a perspective on computer-based educational technologies, relevance to distance education in the PNG, educational context, and a literature review of studies into the efficacy of computer-based instruction systems up to the present. The Literature review looks at how successful the computer-based instructional systems were and their implications in the PNG educational context.

Chapter 4 describes the general methodologies employed in the study and the pilot study including the analysis and discussion of the results from the pilot study. The chapter provides a descriptive account of the general methodology used, including sampling methodology, in the pilot study and later in the main study, the development of the research instruments and the piloting of the instruments. The development of the CAI software used is also described here.

Chapter 5 provides a descriptive account of the main study together with discussions of changes to the original design resulting from the insights gained in conducting the pilot study. The chapter thus provides a description of the general procedures and methodology used in the conduct of the main study, a discussion of the Sampling and Research Population Parameters used in the main study and brief descriptions of the five instruments used in the main study. Changes to the CAI software following it trialing in the pilot study is also presented here as well as A brief description of the computer software version used in facilitating the main study.

Chapter 6 presents the results and analysis from the main study. There are ten sections to this chapter. The descriptive results from the MAQ, CSQ1 and CSQ2 are presented in section 6.2. A brief description of the pretest, posttest and the final examination is presented in section 6.3. Section 6.4 is a description of the factor analysis of the MAQ data. This description includes the rationale for the factor analysis as well as the process of factor analysis employed and the outcome. The validity and the reliability of the constructs derived from the MAQ instrument through factor analysis are also presented in this section. Section 6.5 presents the results of the statistical tests of hypotheses and differences in attitudes to mathematics between the CAI group and the TM group. The results explore the possibility of statistical bias in the sampling method employed in the main study. Section 6.6 explores the linkage that might exist between the number of attempts at doing mathematics 2 and performance in the posttest and the final examination. Establishment of an association between the number of attempts and performances, particularly in the posttest, would mean that factors other than tutorial mode were at play. Thus the results would not be addressing the primary purpose of the study, i.e. differences in performance due to tutorial mode. Sections 6.7 and 6.8 argue the cases for the validity and the reliability of the pretest and posttest scales within the context of the mathematics 2 course objectives. Section 6.9 presents the results of the comparison in performances between the CAI group and the TM group using the Mann Whitney U test on the pretest, the posttest and the final examination.

Chapter 7 provides the discussion of the main results of the study and the findings of the study together with the recommendations and the conclusions.

# Chapter 2: A PNG and a Distance Education Perspective for the Study

## 2.1 Introduction

Distance education at the tertiary level has been in existence at the University of Papua New Guinea (UPNG) since 1975 as Extension Studies under the Extension Studies Department. The Extension Studies program began at UPNG following the *Report of the Committee of Enquiry into University Development* otherwise known as the *Gris Report* (Gris, 1974).

Although the "extension studies" program began in the mid 1970s, it was not until 1985 that the program took on a more significant profile within the University's overall programs. The University made significant staff appointments to the Extension Studies Department and appointed a director of extension studies for the first time in that year. Following this the student enrolment jumped significantly in 1985 (Markowitz, 1995).

A reconstitution of the Extension Studies Department in 1994 resulted in the creation of the Institute of Distance and Continuing Education (IDCE), the organisation responsible for managing and operating the public outreach program (distance and continuing education) of UPNG. Today the Institute of Distance and Continuing Education offers a range of Pre-grade 12, matriculation (grade 12), diploma and degree programs, through a mix of distance and face-to-face approaches.

The discussions in this chapter place PNG distance education in perspective, both in terms of PNG as a developing nation with its own unique challenges and its educational development. A discussion of the field of distance education and its theoretical development is also included in order to provide a theoretical basis for PNG distance education. The discussion includes definitions of distance education, an historical perspective and the theoretical thinking and debate in the development and practice of distance education. The discussions include mention of some of the major players in distance education who made attempts at providing a theoretical basis for the practice and conduct of distance education. Some insight is also provided into the debate on whether distance education is a specialised field of education that is a separate and distinct form of education or otherwise. A question considered is "does this distinctness, if present, remain under the impact of the new educational technologies?" The direction that distance education has taken under the influence of the new educational technologies is also briefly visited.

The debate between behaviourist and constructivist notions of learning and their implications for distance education in the PNG context is also important and is therefore considered briefly in this chapter. The chapter then progresses into a consideration of the development of distance education, in PNG. The chapter concludes with a discussion of some PNG contextual issues. In particular two questions are considered: Can access to tertiary eduction in PNG be improved through distance education? Are the pedagogical orientations of distance education anathema to the cultural orientations of Papua New Guineans?

## 2.2 The PNG Context: Perspectives of Geography, History, Politics and Education Including Distance Education

In order to discuss distance education in the Papua New Guinea cultural context a perspective of Papua New Guinea geography, history, politics and education is necessary.

The next few sections outline discussions of these perspectives highlighting why distance education can help in the provision of educational services to greater numbers of the people of Papua New Guinea, and more efficiently.

### 2.2.1 Geography, Demographics, Culture and Languages and Politics of Papua New Guinea in brief

The following subsections briefly present and discuss the geography, demographics, the culture, languages and the political situation in PNG.

#### 2.2.1.1 Geography and Demographics

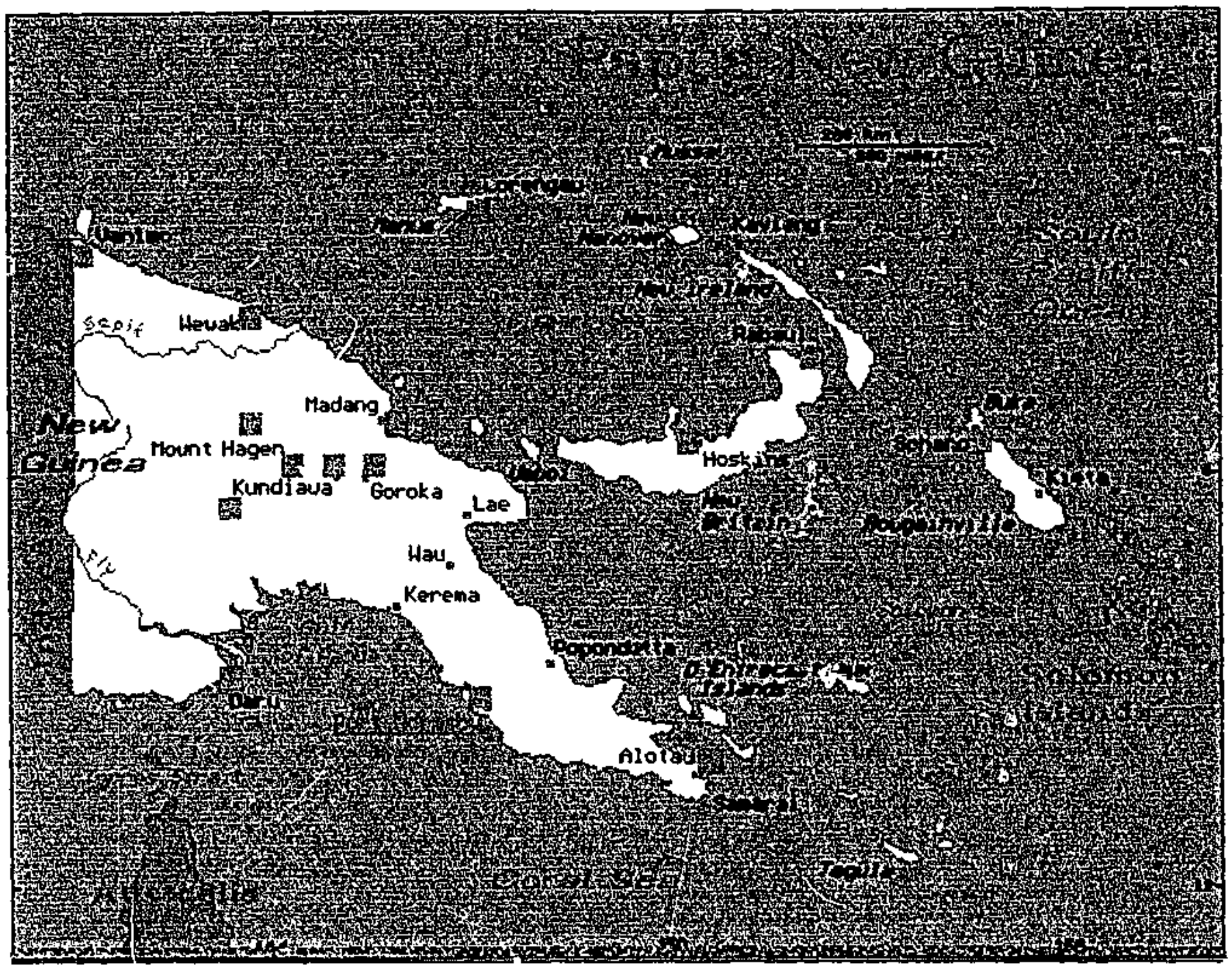
Papua New Guinea, as the map in figure 1.1 below shows, includes the eastern half of the Island of New Guinea, the second largest non-continental Island in the world. The country is composed of an estimated 600 islands of varying sizes with Bougainville, New Britain and New Ireland the biggest of the other Islands. The western half of the Island of New Guinea is the Indonesian province of West Papua.

Papua New Guinea shares close common borders with Australia immediately to the south, Indonesia immediately to the west and the Solomon Islands to the South East. It also shares borders with other countries, most notably Guam and other Micronesian States to the north, but is separated by vast expanses of ocean from them.

At the last census, National Census 1990, the population of PNG was estimated to have reached 3.75 million people scattered over an area of over 460,000 square kilometres of land and sea; an area which is twice the size of the United Kingdom. Preliminary figures from census 2000 released on the 26th of July 2001 (Population 5m, 2001; Turia, 2001) shows a population of 5.13 million, which is much higher than variously estimated prior to the release of the Census 2000 results. This represents an annual growth rate of 3.1 percent for the decade since 1990 and a population density of some 11 people per square kilometre, up from 8 people per square kilometre since 1990. The population has grown by about 36 percent since 1990.

While a population density of about 11 people per square kilometre may not indicate over-population, the population estimate of almost 4 million in 1990 represents a near doubling of population since 1966 when it was estimated at around 2.2 million (Census, 1980; Turner, 1990). A population of 5.13 million in 2000 represents a near three-fold increase in the population since 1966. In other words the population has almost trebled in 34 years. This is despite the fact that PNG has one of the highest infant mortality rates in the world as well as a comparatively low life expectancy. PNG ranked 133 out of 174 countries in 2000 on the "Human Development Index (HDI)" in life expectancy, income and education (UNDP, 2000).

*Figure 2.1 Map of Papua New Guinea*




Given the annual rate of growth of the population of 3.1 percent, there will be more than 7.5 million Papua New Guineans by the year 2015. In 1990 the average age of the population was estimated at 27.5 years and about 85 % of the population lived in rural areas (Census, 1990).

There are four distinct regions in the country, a direct consequence of its natural geographical demarcations. The regions are, the Highlands with 38.2 % of the population, Northern coastal New Guinea (MOMASE) with 27.8% of the population, the southern coastal region (usually known as Papua) with 20.2% of the population and the Islands with 13.8% of the population (Census, 2000).

Since the introduction of provincial governments not long after independence, the number of provinces now stand at 20, including the National Capital District (NCD) and Bougainville.

#### 2.2.1.2 Transport and Infrastructure

There is very little by way of road networks connecting various regions or provinces. Therefore most inter-provincial travel is undertaken by air, even where the provinces are on the same landmass. There is also a lot of inter-island sea travel for the coastal and Island provinces.

The longest road system in the whole country, the Highlands Highway, connects all five Highlands Provinces with the coastal cities of Lae in the Morobe Province and Madang in the Madang Province. Besides the enormous cost of building roads in a mountainous country with very rough terrain, many people, particularly in the southern region do not want a direct road link from other parts of the country. The main reason for this is to discourage the expected urban drift to the National Capital.

#### 2.2.1.3 Culture and Languages

The country is culturally very diverse as indicated by the more than 750 languages spoken. The development of three lingua francas in the country makes inter-communication on a day to day basis in education, politics and commerce possible. The lingua francas are Police Motu, mainly spoken in the southern region, Tok Pisin, a form of Pidgin English, and English. Of the three official languages, Tok Pisin is more commonly and widely spoken in the country. English is the official language of government, commerce and instruction in schools, although it is now government policy that the first three years of elementary education is conducted in the local vernaculars. On the latter point the PNG Minister of Education has recently declared all languages in PNG official languages of Education, in an obvious reference to the first three years of schooling in the local vernaculars (Education Plans, 2001; PNG Languages, 2001).

#### 2.2.1.4 Politics

Papua New Guinea became politically independent from Australia in 1975 although Australia has had a continuing interest in the progress of the country in providing budgetary aid and other forms of support ever since. The budgetary support ceased completely in the year 2000. Australia now provides project-specific aid only, which is still substantial nonetheless.

There are two tiers of government, the national government at the top and the provincial government at a more local (provincial) level. At the provincial level there are 20 provinces each with its own provincial government with a provincial governor heading the government. The provincial governor is usually a member of the national parliament. The National Capital District (NCD) has a slightly different structure of provincial government because of its nature as the Capital of the nation.

The situation of having two levels of government leads to situations where for instance in education there are provincial functions and there are national functions. Problems often arise in providing education services to the people when the allocation of functions is not properly defined and the responsibility is juggled between the two levels of government without either level of government assuming responsibility.

The education system, which is discussed in the next section, has developed against this backdrop of geographical, demographical and social background and political governance.

### 2.2.2 A Concise History of Education in Papua New Guinea

The history of formal education in Papua New Guinea in the modern sense is relatively short. The missionaries started the first schools in the late 1800s with the primary purpose of spreading the Gospel and the essentials of their faith as widely as possible by enabling the people to read the Scriptures (Conroy, 1979; Dickson, 1976; Latukefu, 1985). According to Weeden, Beeby and Gris (1969) other associated aims were to promote full participation in church activities and better living practices.

Luisson (1970) stated that the aim of the missions was:

> To develop character and personality, prepare children to grow up as good Christians and useful members of society, to advance cultural development and to promote a healthier existence.

The appointment of the first government director of education in 1946 marked the formation of the Department of Education when the former territories of

Papua and New Guinea came under joint Australian administration. The schooling provided by the missions prior to World War II was essentially pitched at the elementary level. The government continued this practice when the post-war period saw an emphasis on the extension of mass literacy.

The Australian Minister for Territories made the declaration in 1955 that "universal, primary education, the blending of cultures, the voluntary acceptance of Christianity by the indigenous people, and the fostering of English as a common language" (Thomas, 1976), were the educational objectives for Papua New Guinea.

It was planned in 1958 that universal primary education was to be achieved in 15 years. The 'United Nations Visiting Mission' of 1962 criticised this plan however as inadequate. The Mission pointed out that the system needed to provide secondary and tertiary qualified Papua New Guineans to replace Australians at independence. A change of plan meant that secondary and higher education began to receive high priority with the establishment of high schools and the forerunners of the University of Papua New Guinea (UPNG) in Port Moresby and the Papua New Guinea University of Technology (Unitech) in Lae (Thomas, 1976).

It was not until 1962 therefore that the first high schools were built (the students were sent to Australian schools for levels above primary school before that).

### 2.2.3 The Education System in PNG

The following sub-sections briefly discuss the development of the education system from just before independence in 1975 up to and including the implementation of major education sector reforms in 1993. The discussion covers factors that influenced the development of both the post-independence education system and the reformed education system.

#### 2.2.3.1 The Education System Pre and Post Independence

The Weeden Report (1969) was the basis for the post-independence education system. The report resulted in recommendations that unified the education systems of the Mission and Church Education Agencies with those of the Department of Education. Prior to the report and the implementation of its recommendations the various Church Education Agencies as well as the Department of Education operated independent education systems. These disparate systems provided education ranging from the primary level all the way up to the tertiary level.

One of the main advantages of the new unified education system was the establishment of a new unified curriculum out of the many disparate curriculums in existence at the time.

The basic purposes of the unified National Education System, which closely reflected the National Constitution (DOE, 1985), were to:

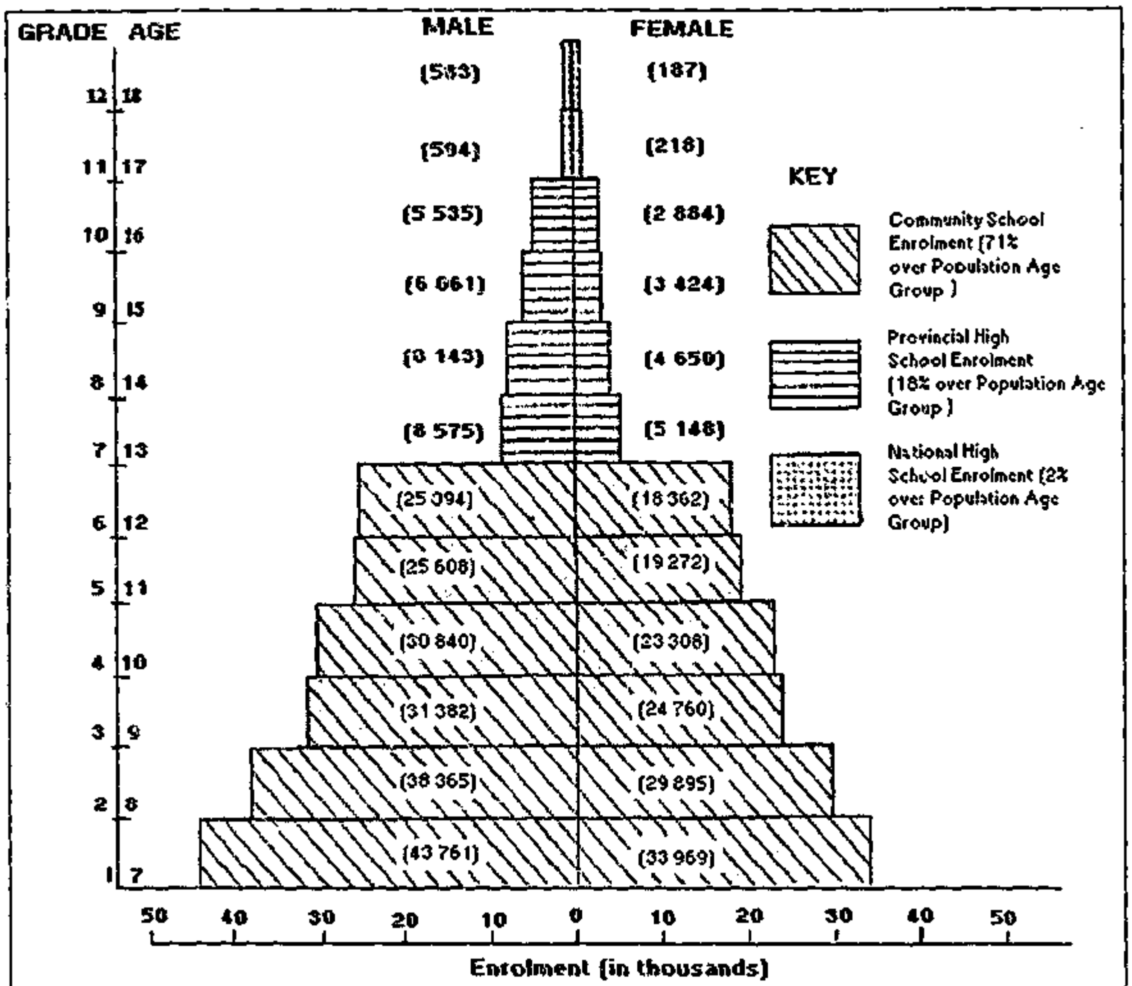
1. Ensure the integral human development of the person
2. Encourage the development of education fitted to the requirements of the country and its people
3. Establish, preserve and improve the standard of education throughout the country
4. Make the benefits of such education available to as many people as possible

Fulfilling these purposes, the education system provided education at three levels: primary, secondary and tertiary.

While the Weeden Report resulted in a unified education system the challenge of providing equal access to education services to as many people as possible remained a problem. Because of the lack of sufficient education resources the distribution of students throughout the education system, from the primary to the tertiary level, had a pyramid-like appearance.

Figure 2.2 below shows the pyramid-like appearance of the student distribution in the education system based on the 1984 enrolment.

*Figure 2.2: The National Education System Pyramid*




**NOTE:** **Total Population in Age Group (93 000) Grade 1 Only**

Figure 1.2: The National Education System Pyramid - Community, Provincial High and National High Schools

*(1980 Population Census, Papua New Guinea)*

The situation was that many children entered the education system and began grade one at the primary school level but a comparatively small proportion of these went on to complete grade 10. Out of this rather small proportion an even smaller proportion, about 2 Percent, continued on to Grade 12. The proportion continuing on to tertiary education was only about 0.5 percent (DOE, 1985).

It is important to note here that the proportion of the population age group enrolled in grade one in the 1984 case highlighted in figure 2.2 represented only about 71 percent of the total population age group. This implies that 29 percent did not even begin grade one. The 1984 case was typical of the enrolment patterns in other years as well.

In the post-independence education system there were cutoff points at the grade 6, grade 8, grade 10 and grade 12 levels. These cutoff points were facilitated by national examinations at the grade 6, grade 10 and grade 12 levels. The education system used the cutoff points as culling points where students were turned out of school, as education resources at the next level up became scarce. The seriousness of the situation for at least the grade 6 children can be imagined when it is remembered that these were 12-year-old children who could no longer continue their general education.

The lack of sufficient education resources notwithstanding, the education system had undergone major changes since independence. For example, 35 new provincial high schools had been built up to 1985 (DOE, 1985) and the tertiary sector had been greatly expanded to cater for the increase in enrolments in secondary schools. By 1985, colleges established included Goroka Teachers' College (now University of Goroka) training teachers at the secondary level, primary teachers colleges, technical colleges and other training institutions.

Up to 1993 there were only 4 national high schools catering for the grade 11 and 12 level of a secondary education. These four national high schools, together with a few other institutions offering grade 11 and 12 classes, accounted for only about 1200 Higher School Certificate (HSC) graduates per annum. This resulted in a rather small pool of HSC graduates for recruitment to tertiary institutions. In fact it was to overcome this situation that the countries universities continued to offer a preliminary year of studies, which covered grade 11 and 12 equivalent level courses, until the mid-eighties.

Under the post-independence education structure the grade 11 and 12 colleges were classed as national institutions and were controlled by the national government, while the provinces were responsible for all community (primary level) schools and Provincial high schools (grade 7 – 10).

In 1991 a major education sector review was conducted and the upshot of this review was what came to be known as the "education reform", with implementation beginning in 1993. The next subsection briefly discusses the education reform and its principal effects on the education structure that had existed from around the time of independence in 1975.

#### 2.2.3.2 The Education System Following the Education Sector Review of 1991

Following the education sector review the education system was greatly expanded with the introduction of the concept of 'Top-up' schools in 1993. The concept of 'Top-up' schools involved tagging grade 11 and 12 classes to established provincial high schools and tagging grade 7 and 8 on to established primary schools. Tagging grade 11 and 12 on to existing provincial high schools was considered more economical then creating more specialized national high schools, which offered grade 11 and 12 classes only.

With the concept of 'Top-up' schools the provinces became responsible for virtually all schooling up to grade 12 because many provincial high schools added grade 11 and 12 classes onto their existing programs.

The education reform has resulted in a general re-organisation of the stages of general education. Previously Community (Primary) Schools went from grade 1 to grade 6, Provincial High Schools from grade 7 to grade 10 and National High Schools offered grade 11 and 12 classes only. This has now been restructured so that community schools now also embrace grades 7 and 8. The high school stage now embraces grades 9 through to grade 12. Thus a three-stage system of general education has now been effectively reduced to a two-stage situation, although the high school stage is variously labelled as lower secondary (grades 9 and 10) and upper secondary (grades 11 and 12).

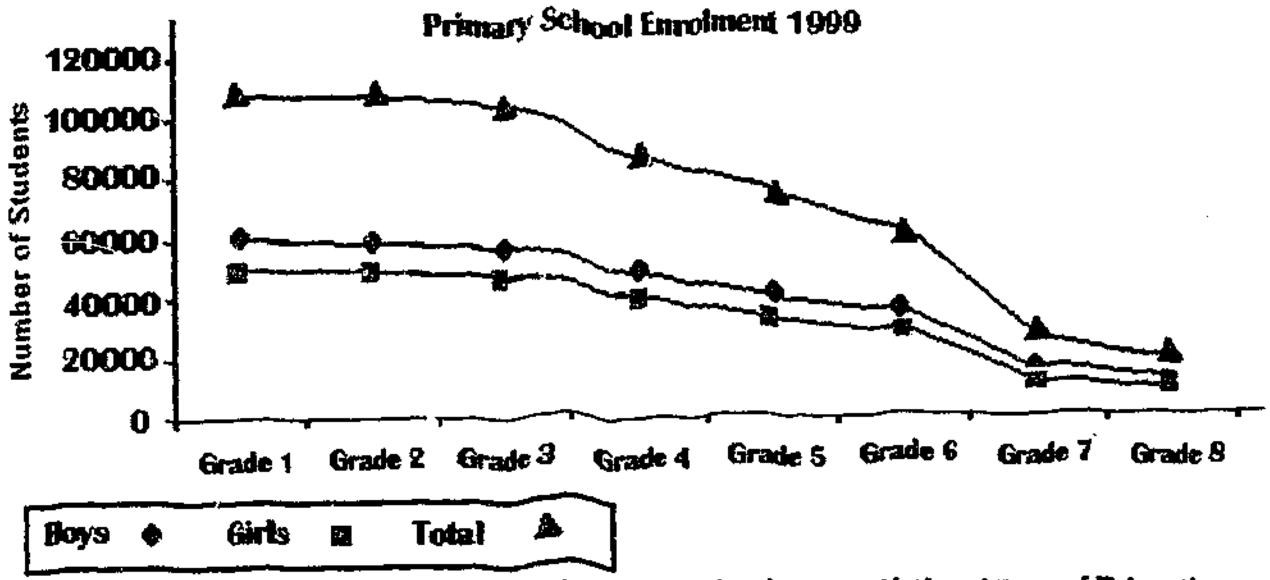
The education reform also proposed that the first three years of schooling is conducted in the local vernacular. This was designed to facilitate the teaching of reading and writing skills to children in a language they already understood and spoke (English is not the first language for the majority of Papua New Guineans). Teaching the children to read and write in a language they already speak means that they are not also learning a new language at the same time which would be the case if they are taught to read and write in English from the beginning.

In a recent launch of a five-year plan on Curriculum and Inservice Management, the PNG Minister for Education said that the use of local languages in elementary schools ensures children are taught in languages they understand. He said that they are likely to be more motivated and more likely to succeed during their first years of schooling using their local vernaculars (Education Plans, 2001). The success or the failure of using the local vernaculars in the first three years of schooling is the subject of an AusAID funded assessment project by an Australian team at present.

The problems that the 1991 educational sector review and subsequent reform addressed were those of greater accessibility to affordable and quality educational services as well as retention of school-aged children for a longer period in the education system. The system as it existed was denying educational opportunities to many more young Papua New Guineans as early as the grade 6 (age 12) level as discussed earlier. Recent statistics announced by the PNG Minister of Education variously estimated an increase of 300,000 - 500,000 students in the education system following the reform, from around 500,000 pre-reform to around a million students post-reform (Education Plans, 2001; Missing Out, 2001). The Euphoria in announcing this significant increase is somewhat tempered though by the equally recent announcement of an estimated 2.75 million school-aged children still with no access to formal education in PNG (Education Failings, 2001; No Access, 2001).

A major effect of the reform is that all students that enter the formal education system can theoretically continue through to the end of secondary school i.e. grade 12. From figure 2.3 below of the 1999 primary school enrolments in grades 1 to 8, it is obvious there continues to be losses from the system right through the primary school years and by extrapolation most probably throughout the high school years as well. The reform has somewhat reduced the magnitude of that loss in contrast to the pre-reform situation. Nonetheless there are still significant losses from the education system in the order of magnitude of some 70,000 children who enter grade 1 but who do not make it to grade 8. The reasons for this significant attrition rate will be many, but lack of adequate educational facilities and resources must figure prominently.

*Figure 2.3: Primary School enrolments 1999*




*Source: The State of Education in PNG - National Dept of Education*

As mentioned earlier, in the post-independence education structure there were at least two cut-off stages (grade 6 and grade 10) at which many students were pushed out of the education system. This caused widespread resentment amongst those forced out.

This is the situation that gave rise to the much-talked about educational phenomenon in PNG called "pushouts" or "dropouts". This is often blamed for the social disenfranchisement of young people who turn to crime to get back at the system that "pushed" them out. The 'pushouts' or 'dropouts' were those who did not meet the required pass rates in the national examinations at grade 6 and grade 10 and discontinued schooling from then on. The 'push out' was neither sufficiently educated to fit into a more skilled work force in the modern employment sector nor taught the necessary skills to survive in the rural, agriculture-based local communities.

One of the major issues that the education reform was meant to address therefore was the generally held public perception that the education system was failing and needed reforming. A ministerial brief from the Education Department (DOE, 1990a: p. 1) attests to this perceived failure of the education system thus:

> Many school graduates are returning to their communities where there is work and opportunities for community-based employment. Our stuaents' education has not prepared them or their parents for this reality.
>
> There is growing concern within the community about this failure of the Education system to help the majority of our graduates to participate positively in the activities of the community.

The failure was accentuated by the examination system, which played a crucial role in the selection process at the various cut-off points (grade 6 to 7, grade 10 to 11, and grade 12 to university). Ross (1991) alluded to this negative aspect of the role of the national examinations system in determining the progress of children's education from one stage to the next in PNG as the 'backwash' effect of examinations. The 1991 Education Sector Review proposed the restructure and reform of the education system partly to address this problem.

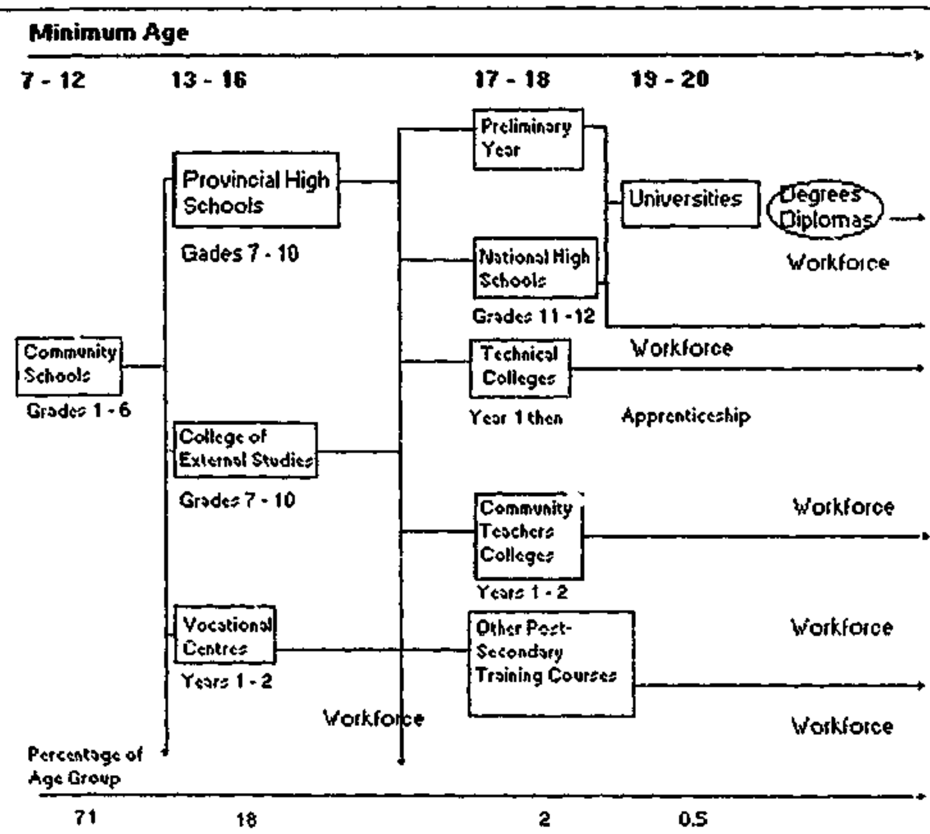
Figures 2.4 and 2.5 below show the structure of the education system in PNG before and after the reform respectively.

The aims of the reform of the education system were to increase intake into universities and the upper secondary schools, increase retention in schools and increased access to schools for the majority of Papua New Guinean children. The summary below lists the effects that the reform was intended to have on the education system.

1. Elementary (k-2), primary (years 3-8), secondary (years 9 -12)
2. Immediate and increased access for 6 year olds
3. Initial literacy and first three years (elementary education) in a language the child speaks
4. Increased retention, ie no "cut off" points at grade 6 and various other grades.
5. Provision of a more integrated activity based curriculum.
6. Increase in access at both upper and lower secondary levels. This was done by establishing "Top up" schools through the inclusion of grades 7 and 8 classes at the primary school level and grades 11 and 12 classes at the provincial high school level.

7. Increased pool of grade 12 leavers for tertiary institutions.
8. Vocational education included within the secondary stage.
9. Development of Subject biases at matriculation level – technical, agricultural and commercial

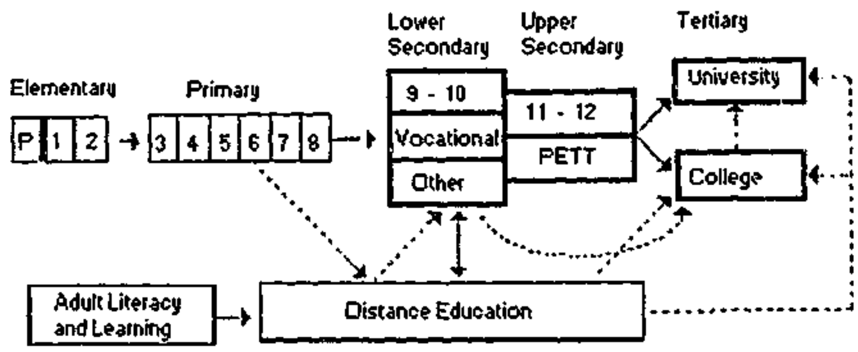
***Figure 2.4: Structure of PNG Education System: Before 1994***




Source : Adapted from *Education Staffing and Enrolment Statistics* (DOE, 1992)

*Figure 2.5: Structure of the PNG Education System: From 1994*

**A New Educational Structure**




**Structure of Papua New Guinea Education System - Post-Reform**

While the education reform addressed the structure of the education system and resulted in some greater access and retention of students over a longer period, other situations were left untouched. Some of these situations were average class sizes and teacher to student ratios, which were on the rather large, even unacceptable side in terms of magnitude. A typical class size was 40 to 45 students in some schools. In some provinces, e.g Western Highlands Province, policies were deliberately enacted to officially raise class sizes to 50 to cope with the demand for school places, particularly at the grade 1 level (Sail, 1989).

In 1989 the average teacher/pupil ratio was 1:32 in primary schools, 1:26 in provincial high schools and 1:21 in national high schools (Management and Planning Unit, 1989). This does not seem to have changed much at all since the reform with recent statistics showing teacher/pupil ratios of 1:31 in elementary schools, 1:35 in primary schools and 1:24 in secondary schools (DOE, 2001)

In the restructured education system, the curriculum was to be an integration of a variety of subjects, including activities from the community and a balance in the four main curriculum strands, namely, Language and Literacy, Vocational development, Social and Spiritual Development, Mathematics and Science. These four main strands were to be developed using guidelines from the Literacy and Awareness, Relevant Education for All, Access and Expansion programs. The programs had detailed directives, which included policies on integration, language and cultural bonding, provincial and community bias and community involvement. (DOE, 1991: p. 169; 1992: p. 3).

The lower secondary curriculum was to have a strong vocational 'skills' component, especially science, which was to have a strong agriculture and environment bias (DOE, 1991: p.10). The emphasis of the curriculum was to make the content practically oriented with possibly an integration of subjects with Ethics and Morals as part of the school curriculum. This was seen as the way to achieve integral human development as enshrined in the constitution.

The common core for the secondary level was to consist of academic subjects (English, Mathematics, Science and Social Science) and a Life Education strand (civics/citizenship, values education, cultural studies, leadership, development studies). The optional vocational courses were to be any combination of agriculture, woodwork, home economics and physical education. The core subjects were to be compulsory at the lower level, they were to be nationally prescribed with adaptations possible in the areas of cultural studies (DOE, 1992: p.4). The curriculum at the upper secondary level (Grades 11 and 12) was to be more academically oriented to prepare students for further education but at the same time allow for curriculum “bias”. Curriculum "bias" involved sandwiching among the academic subjects other subjects considered practical for daily living in a developing country situation like PNG, such as commerce and agriculture (DOE, 1991: p.82).

### 2.2.4 A Major Implication of the Education Reform

While the education reform resulted in the expansion of the primary and secondary levels of the education system, there has been no corresponding expansion of the tertiary sector. The consequence of the lack of expansion of the tertiary sector is a bottleneck between completion of matriculation (grade 12) and tertiary education. Student places at the higher education institutions such as UPNG are insufficient to accommodate all eligible applicants from secondary schools and IDCE matriculation. There are no immediate prospects for the expansion of facilities at the higher education institutions to accommodate the demand for study places.

### 2.2.5 A Cultural Perspective on the Education Reform in PNG

The researcher noted in the previous section the perception by many that the education system post-independence in PNG was failing. In response to that perception, the Government of PNG formed a Ministerial Review Committee on the Philosophy of Education. The committee was chaired by Sir Paulias Matane, a retired senior public servant, and included other prominent and respected citizens of PNG. The Committee presented its findings on November 1986 (Matane, 1986). The terms of reference of the Committee were:

1. To critically examine the philosophy implied in existing plans and practices of the National Education System
2. To determine if, and to what extent, this philosophy is consistent with the National Goals and Directive Principles as expressed in the National Constitution
3. To determine whether this philosophy is carried out in educational activities and expressed in educational materials in the institutions administered by the National Education System
4. To analyse the implications of this philosophy for the future development of all sectors of the National Education System

In particular the Committee's deliberations addressed the following questions.

1. What kind of citizen should we now be educating?
2. What kind of education is necessary to produce this citizen?
3. How can we improve the Education System in order to provide this education?

The philosophical re-definition that resulted from the Committee's deliberations called for the education system to be relevant to the social, spiritual and resource development needs and opportunities for the majority of its citizens. The

Committee after consulting widely and in particular taking note of the national constitution recommended the following:

1. The philosophy of education for Papua New Guinea acknowledges the national goals and directive principles in the national constitution, and is based on integral human development...
2. This philosophy is for every person to be dynamically involved in the process of freeing himself or herself from every form of domination and oppression so that each individual will have the opportunity to develop as an integrated person in relationship with others. This means that education must aim for integration and maximising socialisation, participation, liberation, (and) equality.
3. This philosophy is based on an awareness of human potential and the willingness to develop this potential so that each individual can solve his or her own problems, contribute to the common good of the society and maintain and promote learning and living.
4. This philosophy presumes the goodness and dignity of every person and so calls for the promotion of self and mutual respect, a sense of self worth and self discipline, and a sense of responsibility for oneself and for others.
5. The ultimate goal of this philosophy is for every person to receive an education which results in **integral human development.**

(Matane, 1986: p. 6 emphasis added).

The recommendations of the Committee have formed the backdrop to all major decisions on educational issues, including the reforms, since. The 1990 national vision for education for instance accepted the culture of the community as the starting point to build on in producing citizens:

- committed to their personal development and view education as a continuing life-long process;
- who have developed a productive work ethic, and value both rural and urban community development activities in a context of national development.

- prepared for life in most communities;
- capable of participating in further training to satisfy manpower needs. (DOE, 1990a).

The understanding of culture used in the 1990 national vision for education is as defined by Lawton (1975) and Skilbeck (1976).

Lawton, drawing from the works of philosophers such as, Bantock, Hirst and Williams, defined culture as "everything that exists in society", and includes "everything that is 'man-made': technological artefacts, skills, attitudes and values". Skilbeck affirmed this anthropological view of culture when he defined culture as *the whole way of life* of a given society particularly as represented by a comprehensive mode of beliefs, values, ideas and life-styles". Lawton also states that curriculum is simply a selection of content made by educationists from the entire range of culture.

## 2.3 Orientations in Distance Education

Although distance education has been in existence for more than 100 years as correspondence study (Holmberg, 1989), it is the development of distance education in the last 20 years that is of greater interest to the present thesis. Keegan (1990: pp. 3-4) in commenting on the relatively recent emergence of modern distance education states:

> For long the Cinderella of the education spectrum, distance education emerged in the 1970s with a changed image. It has recently come of age after a chequered and often criticized first hundred years.

The discussions in the following sections therefore focus on distance education as facilitated by computer-based education technologies. As pointed out in chapter 1, the government of PNG is increasingly looking towards distance education mediated by computer-based educational technologies to overcome the problem of lack of access to education, especially at the tertiary level. While the education reform has increased student numbers at both the primary and secondary levels, the tertiary level in PNG has remained static. The Vice Chancellor of UPNG recently noted in a media statement the inability of the PNG Government to expand tertiary education in its 'traditional form'. He was commenting in the context of a renewed effort by UPNG to embrace distance education as the means to expanding access to its courses (Threat to DE, 2001).

## 2.4 Distance Education Defined

An important starting point in addressing issues in distance education is to focus attention on the prevailing definition or definitions of distance education proposed by prominent figures and practitioners in recent years. The following is a very brief consideration of some of the definitions proposed by leading figures and contributors in distance education including more recent definitions embracing the influence of newer educational technologies.

Holmberg (1977: p. 9) used the term *distance education* to refer to

> The various forms of study at all levels which are not under the continuous, immediate supervision of tutors present with their students in lecture rooms or on the same premises, but which, nevertheless, benefit from the planning, guidance and tuition of a tutorial organization'.

Keegan (1983), in summarising various definitions proposed by Holmberg, Peters and Moore amongst others, arrived at the following six points as essential to what he saw as a comprehensive definition of distance education.

- separation of teacher and student
- influence of an educational organization especially in the planning and preparation of learning materials
- use of technical media
- provision of two-way communication
- possibilities of occasional seminars
- Participation in the most industrialized form of education.

(Keegan, 1983)

The six defining points by Keegan have formed the basis of most subsequent definitions of distance education in the modern sense. This is the case even where the mediation of the newer educational technologies are given prominence in the definition/s. Garrison (1989) noted that the definitions of distance education have endured and remained unchanged for a number of years.

Garrison and Shale (1987a) and Garrison (1989), while generally agreeing with Keegan's six defining points, argued that they were somewhat too narrow and more biased towards the print-based form of study. They claimed that the six points somewhat excluded more recent developments in computer-mediated communications (CMC) technology. CMC covers a class of computer-based communications technologies often used in the distance education setting to mediate instruction and learning that to many is quite revolutionary. Chapter 3 provides a full definition of CMC in the context of the present study.

The limitations of Keegan's definition are probably understandable considering that they almost pre-date some of the newer more effective electronic educational media. In view of the perceived limitations of Keegan's definition, many, for example Barker et al. (1989) and Garrison and Shale (1987a), have called for a broadening of the definition of distance education to embrace the newer educational technologies.

Garrison and Shale (1987a) for instance proposed the following refinements to Keegan's definition in the light of developments in Computer-based educational technologies.

- Distance Education implies that the majority of educational communication between (among) teacher and student(s) occurs non-contiguously.
- Distance education must involve two-way communication between (among) teacher and student(s) for the purpose of facilitating and supporting the educational process.
- Distance education uses technology to mediate the necessary two-way communication.

Most recent attempts at defining distance education recognise the separation of the teacher and student by time and space as being the hallmark of distance education (Keegan, 1990), but in the modern sense technology mediates this separation.

Recent working definitions by providers of distance education are more similar to what Garrison and Shale proposed in their three criteria. For instance the University of Wisconsin's Extension section (Distance Education Clearinghouse, 1998) defines distance education as;

> A planned teaching/learning experience that uses a wide spectrum of technologies to reach learners at a distance and is designed to encourage learner interaction and certification of learning.

Virginia Steiner (1998) of the Distance Learning Resource Network (DLRN) defines distance education as "Instructional delivery that does not constrain the student to be physically present in the same location as the instructor". She makes the point that the more common delivery modes in recent times have been audio, video and computer technologies.

A brief session spent surfing the web for institutions providing distance education courses around the world produces about as many definitions as there are institutions. In all the definitions the essential point seems to be any formal approach to learning in which the majority of instruction occurs while the educator and the learner are at a physical distance from each other. Simply put modern distance education would probably be described as taking instruction to the student through technology rather than the student to the instruction (Distance Education Clearinghouse, 1998).

These definitions in essence capture the more contemporary understanding of what distance education is in the current context of increasing electronic modes of course delivery as opposed to print-based course delivery.

The next subsection briefly focuses on an historical perspective of distance education.

## 2.5 Brief History of the Growth of Distance Education

Historically distance education, just like its predecessor correspondence education, was mainly print-based (Bates, 1991), a practice that is still prevalent in many cases and is certainly still the case in Papua New Guinea.

Distance education as a form of learning is of rather recent origin according to Koul and Jenkins (1990). It only began to gain prestige in recent years culminating in the establishment of institutions like the Open University in 1969 and other like institutions with similar missions to the Open University as noted for instance by Bates (1991) and Garrison and Shale (1990). Organised forms of correspondence education had existed for up to a hundred years before that (Baath, 1979), usually set up as private business organizations more concerned with profits than anything else, but with few exceptions (Perry, 1981).

The reason for the adoption of the term distance education in place of correspondence education was the formal recognition of the significant changes that had taken place in the delivery of education at a distance (Garrison, 1989). It was very quickly realized given the rapid growth in the use of media other than print that the term correspondence education (study) was too narrow (Markowitz, 1994). In recognition of this change, the International Council for Correspondence Education (ICCE) in 1982 changed its name to the International Council for Distance Education (ICDE) (Garrison, 1989; Holmberg, 1986) thereby catapulting the term distance education into greater prominence.

## 2.6 Towards an Overarching Theory for Distance Education

It has been claimed for instance by Sewart, Keegan and Holmberg (1983), that a lack of an accepted theory has weakened distance education to the point where it is seen as "fragile, belonging to the periphery and lacking in identity". Keegan (1990) observed that the search for a well-grounded theory of distance education had been difficult.

The few names listed below of educators who proposed general statements about the practice of distance education, provides an indication of educators who thought that it was possible to derive an overarching, all-embracing theory of distance education. Holmberg (1986: p. 103), writing in support of a comprehensive theory of distance education, states that:

> Attempts to look into the feasibility of a theory of teaching for distance education as well as a description of what could constitute a more comprehensive theory of distance education are overdue.

Elsewhere (Ibid: p. 107) he states that:

> A theory explaining and predicting occurrences in distance education is imaginable as far as teaching and learning are concerned.

Perraton (1987: p. 11) on the other hand doubted that such was possible when she stated that "it is naive to seek a single theory of distance education".

The use of the term 'theory' in the context of distance education or education in general somewhat conflicts with the sense in which scientists apply the term in the field of science. If the word 'theory' were to be used in its strictest scientific sense it would exclude ideas in education from being classed as theories (Campbell, 1953; Nagel, 1969). Holmberg (1986) and Perraton (1987) go to some length in justifying the use of the term as well as explaining the sense in which the term is used in the education context which includes distance education.

The use of the term in the present thesis therefore is no more than a reflection of the use of the term in the distance education literature. In the context of the present study, therefore, and in all subsequent references in the present thesis, the educational sense of the term prevails. This qualification is important to note wherever the term 'theory' occurs in any subsequent discussions concerning the development of ideas in distance education.

Keegan (1990) and Garrison (1993) noted that certain underlying assumptions are made in classifying thinking in distance education as theory. Keegan (1990: p.6) noted four assumptions summarised as follows:

1. Distance education is a coherent and distinct field of educational endeavour embracing all levels of the educational experience in both public and private sectors.

2. Distance education is a complete system of education providing educational programmes for both children and adults outside of, and distinct from, conventional, oral group-based provision. Having its own laws of didactical structure and its own quasi-industrial administrative procedures.
3. Distance education is a form of education fraught with problems for administrators, teachers and students. It is characterised by the fragility of the non-traditional in education.
4. Distance education is a needed component of most national educational systems.

Sauve (1993) points out that the so-called theories in distance education are really a number of models relating to the practice of distance education because there is no overarching theory or concept of distance education. Rumble (1988) expressed the view that the theories in Distance education are still nothing more than generalizations drawn from practices and could not be considered to be independent of general educational theories. In keeping with the trend in the existing literature of distance education however, the present thesis refers to the development of ideas in the practice of distance education and the proponents of those ideas, as theory and theorists respectively.

Wedemeyer (1974) highlighted the assertion that distance education has suffered due to a lack of a coherent body of ideas (theory) when he stated that:

> It is unfortunately true that the failure of correspondence study to develop a theory related to the mainstream of educational thought and practice has seriously handicapped the development and recognition of this field.

Sewart et al. (1983) and Keegan (1990: p. 52) categorised into three groups the main directions of distance educational thought and ideas and the main proponents of each category. The three categories are:

1. Theories of autonomy and independence
2. Theory of industrialization

3. Theories of interaction and communication

The main proponents of the theories of autonomy and independence were Rudolf Manfred Delling, Charles A. Wedemeyer and Michael G. Moore. Otto Peters was the main proponent of industrial theory and Borje Holmberg, John A. Baath and David Sewart took theoretical positions in the areas of interaction and communication.

The following are brief summaries of positions taken by each of the educators named above in the three categories. Except where specific, different references are cited, the information is derived from Sewart et al. (1983) and Keegan (1990).

According to Sewart et al. (1983), Delling held that distance study was an artificial dialogic learning opportunity in which the physical distance between the learner and the helping organization is bridged by an artificial signal carrier. He reduced the role of the teacher and the educational organization to a minimum placing the greater emphasis on the autonomy and independence of the learner.

Wedemeyer idealised a democratic social view and a liberal educational philosophy whereby everyone had equal opportunity regardless of economic status, geographical location, social position, health and anything else that might work against a person's educational development. He also held that 'independent study' should be self-paced, individualized and goal-free.

Moore classified educational programs by the variables of 'distance' and 'learner autonomy'. He recognized that learners varied in the extent to which they exercised autonomy. He concluded that neither distance nor learner autonomy could be measured in physical terms and hence saw no value judgements in the terms autonomy and distance (Moore, 1983).

According to Sewart et al. (1983) and Keegan (1990), Otto Peters concluded from his extensive study of distance education institutions "that distance education could best be analysed by comparison with the industrial production of goods". His applications of the categories of industrial theory to distance education led him to conclude that the theory of industrialisation was the best explanation of distance education because it was the most industrialized form of education.

Holmberg (1989) described distance education as a 'guided didactic conversation' between the student and the supporting organization. He concluded that self-study is essentially different to private reading in that the student is not alone in self-study.

Baath's main area of investigation and thought was in 'two-way communication by all means available' at the time in correspondence education. Sewart proposed that there was a need for a continuing concern for the student's learning at a distance, that it was not sufficient to simply send a package of materials to the student to perform the functions of the teacher. He saw the continuing need for a distance institution to provide support and advise to the student in addition to the provision of a teaching package.

For the purposes of the present thesis, the foregoing is sufficient to establish some of the issues that the development of the practice of distance education has gone through to arrive at the present situation.

## 2.7 Criticisms of Theories of Distance Education in two Contexts

The two subsections immediately following present criticisms of theories of distance education on two fronts, which the researcher considers sufficient to show the futility of the search for an overarching theory of distance education. The two fronts are the behaviourism versus constructivism debate in education and the industrial model of distance education.

### 2.7.1 Criticisms of Theories of Distance Education in the Context of the Behaviourism versus Constructivism Debate

More recently the views presented in section 2.6 have been criticized as being somewhat preoccupied with and excessively influenced by access issues based on thinking that was seen to be biased towards behavioural orientations (Garrison, 1993). It was felt that insufficient regard is paid to issues of quality in teacher-student interactions as highlighted by recent developments in technology and the paradigmatic shift in educational thinking that as come about as a result.

Moore (1993a) supported this when he observed that, "in the early 1970s distance education was dominated by behaviourists" and therefore behaviourist thinking. Jegede (1991) concurred when he observed that procedures for designing instructional materials, where pre-packaged course materials with pre-determined outcomes were the norm, were based on the now largely superceded notions of behaviourism promoted by positivist thinkers. The view of learning as mere cumulative accretion of knowledge by behaviourist thinkers, has largely lost support in recent years. Jegede (1991) echoes the thoughts of such eminent thinkers as Jean Piaget, Von Glasersfeld and others in stating that, "learning is an active interpretive process of constructing and generating ideas to explain occurrences".

In distance education, there is a need therefore to resolve the tension that exists between pre-determined learning outcomes as in pre-packaged courses and constructivist notions of the individual student negotiating his or her own learning. This tension obtains full expression in the physical distance that exists between the learner and the instructor. In the modern sense the distant educator, through the most effective choice of media, acts the part of a facilitator only, instead of the communicator of a fixed body of information (Perraton, 1988). In text-based correspondence courses, pre-packaged course materials with pre-determined learning outcomes were seen as necessary because of the physical distance between instructor and learner. Otherwise, the student was completely alone with the two-way communication occurring at best over a drawn-out period. This situation somewhat diminished the effectiveness of the two-way communication.

This tension is particularly problematic in the PNG context where text in distance education assumes the aura of the source of all knowledge and stands unquestioned, as noted by Guy, Haihuie and Pena (1996) for instance. The situation is complicated further because PNG traditional culture is oral in nature and text-based learning is a new paradigm that PNG children only assume as they enter the formal education system.

How is this tension resolved? An answer to this question is computer-based educational technology. According to Barker, Frisbie and Patrick (1989) computer-based educational technology bridges the geographical distance between the instructor and student. In the current state of technology, this bridging can occur very often to a near face-to-face level of communication although there is physical distance between the instructor and the student.

### 2.7.2 Debunking the Industrial model of Distance Education

A theory, noted in section *, that has come under increasing criticism recently is Peters' industrial model of distance education. Rumble (1995a) for instance takes issue with the three theses that underlies Peters' industrial model. These are:

1. Distance education is an industrial form of education. As an industrial form of education.
2. Distance education differs markedly from traditional education, which is a craft.
3. There has been an evolution over time from pre-Fordist to Fordist to neo-Fordist forms of production.

Rumble compared distance education with modernist and post-modernist models of work, namely Fordism, neo-Fordism and Post-Fordism and found contradictions in these assertions. He noted for instance that there were non-industrial forms of distance education and there were aspects of " 'traditional' classroom and group-based forms" of education which were industrialised. He thus concluded that industrialisation was not the characteristic that best defines distance education. In a follow up article, Rumble (1995b) stated that "no one theoretical framework actually encompasses either the whole of distance education or even the whole of an organisation such as the Open University".

To be fair to Peters, he did address some of the criticisms to his 'theory' in an article in the Journal, *Open Learning* (Peters, 1989) where he replied to 10 'misunderstandings'. In 'misunderstanding 5' he stated that he never considered the descriptive statements resulting from his observations, that distance education is an industrialised form of education, as a theory. He stated that despite the general statements of his observation of distance education compared to 'traditional' forms of education "distance teaching remains teaching and distance education remains education".

## 2.8 A cognitive/constructivist view of Distance education

This section very briefly provides a constructivist context for the present study and the intention is not to produce a substantial treatise for the idea of constructivism. Constructivism is a big idea that has occupied numerous volumes of literature but is outside the scope of the present study.

New insights in to adult learning have engendered a move away from behaviourist models of learning, which are based on the belief that knowledge can be transmitted from the educator to the student (Pepin, 1998; von Glasersfeld, 1996). Renshaw (1995) labelled this view of learning the 'transmission model' of teaching and learning because the teacher transmits knowledge to the student.

The theory of constructivism holds that the learner constructs his or her own knowledge within a given social environment (Jegede, 1992). Every human being assembles the bits and pieces of life's experiences in ways that in many respects are unique. Hackbarth (1996) states:

> Drawing upon prior conceptions and feelings, we actively interact with our surroundings in an on-going effort to make the diversity of our experiences all sensible and coherent.

Referring to the idea of constructivism von Glasersfeld (1996: p.3) stated that "what we call knowledge does not and cannot have the purpose of producing representations of an independent reality, but instead has an adaptive function". He goes on to state that " when we intend to stimulate and enhance a student's learning, we cannot afford to forget that knowledge does not exist outside a person's mind (Ibid: P5). He proposed that changes in the students' ways of thinking are possible only if the educator had some idea about the domains of experience, the concepts and the conceptual relations the students had to start with.

According to Ginsburg & Opper (1979), Piaget, considered one of the leaders in constuctivist thinking, concluded from his research on the intellectual development of children that it is through action and not passive observation that a child develops an understanding of the world and constructs reality. He believed that reality does not simply impose itself on a passive organism. The individual assists in the active construction of his or her own reality by interacting with the environment and intellectually constructing his or her own meaning of these encounters with the environment.

Learners revise, reorganise and reinterpret old knowledge with new input i.e. learners act upon their environment and do not simply respond to it. Greening (1998) notes that even in its most theoretically trivial sense constructivism holds that "learning occurs as an act of cognitive restructuring rather than transmission".

Of more significance to the distance education debate as seen from the behaviourists point of view is the suggestion that information cannot be absorbed either from the teacher or from textbooks (Young, 1998). This observation is at odds with both the theoretical bases of pre-packaged course materials with pre-determined learning outcomes as well as the view that teachers/instructors are necessary for learning to happen.

An essential ingredient to cognitive learning processes is motivation. Weiner (1979) documented the importance of motivation to the constructivist learning paradigm. Motivation is necessary to facilitate engagement in cognitive processes. Even Piaget recognised the essential nature of motivation to the learning process.

One way that computer-based educational technologies facilitate cognition is through the motivation of the learners to engage in the learning process through interactive computer software. Computer-based communications technology can also bring about a level of two-way communication between the instructor and learner that is vastly different from text-based correspondence-style courses, thereby facilitating a constructivist learning ideology. Chapter 3 provides further consideration of the link between constructivist notions of learning and computer-based learning modes.

## 2.9 Phenomenal Growth of Distance Education

The growth in interest in the field of distance education in recent years has been nothing short of phenomenal, as noted by many writers (e.g. Smith (1987), Garrison and Shale (1990) and Koul and Jenkins (1990)). According to Garrison (1987b) much of the recent focus on distance education stemmed from a growing demand for educational opportunities designed for and targeted towards specific groups. Lauzon and Moore (1989) observed that distance education was emerging as a real force in education and was moving from a marginal role to 'front and center'.

While some, as noted by Sewart et al. (1983), saw distance education as a peripheral activity, lacking in identity, others, for example Lauzon and Moore (1989) noted the shift to centre stage of distance education in recent years. Guy (1991) noted that in many developing nations, distance education has been at the centre of educational practices, quoting Kenya, Zimbabwe and Zambia as examples.
Guy also notes the enthusiasm with which supporters in the developing world acclaimed the potential of distance education. One suspects that a major reason for the enthusiasm with which distance education was hailed was its potential for facilitating mass education. Arger (1990) alludes to this connection when he noted:

> It is clear fro... literature that distance education promises to assist national development, particularly in the third world. It started in the late 19th century with correspondence education promising to provide cheap egalitarian, mass education of good quality.

As noted earlier (section 2.6), Peters likened the practice of distance education to the industrial process where costs in production come down with scale of operation and numbers. Many developing countries faced with increasing populations and diminishing resources would find the supposedly cheaper means for mass education for its people facilitated by distance education in the industrialised model rather attractive.

While many amongst the developing nations are excited about the potential of distance education to fa...te mass education not everyone involved in distance education in the developing world is enamoured with it. Arger (1990) for instance concluded from his observations of the practice of distance education in three developing nations that there is a vast gulf between the promise and the reality of distance education.

## 2.10 Models of Distance Education

There are many models of distance education, in existence all over the world today. In fact, no two-distance education operations, even in the same country, are the same. Various institutions, even within one country conduct their distance education offerings differently to others. The scope of the courses offered and what denotes distance education also varies from institution to institution.

The Institute of Distance and Continuing Education of the University of Papua New Guinea follows a model called the New England Model. The New England model is characterized by practices where the residential course structure of an institution is closely reflected by the extension program (Markowitz, 1994). This implies that each course has a fixed starting and ending time, a fixed schedule of assignments, a fixed duration and a fixed examination schedule. A major disadvantage of this model in PNG is the high level of regimentation which students who have to sandwich their studies in between other obligations often find difficult.

## 2.11 The necessity of Distance Education in PNG

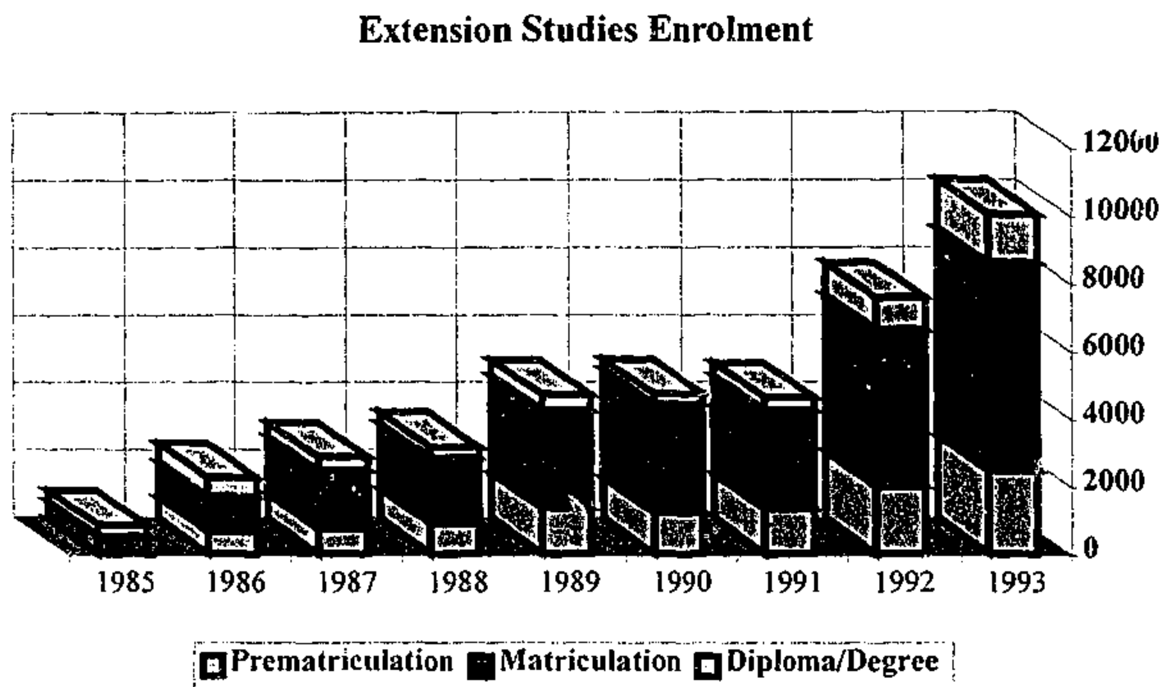
The following subsections provide a PNG context for distance education. Discussed are some issues that establish the importance of distance education in the PNG education outlook.

### 2.11.1 Education Access Issues in PNG

The problems of access to education has already been visited in noting that up to the late eighties about 29 percent of the population age group entering grade one did not even start. Given the rate, at which the population of PNG is increasing as revealed recently by the release of the Census 2000 results, the demand for education continues to outstrip the available education resources. Even at the present time, there is still a situation of inadequacy in the provision of educational services and access to those services by many Papua New Guineans. This gap has narrowed somewhat in recent years especially with the implementation of the education reform. Unfortunately, while the education reform in PNG has resulted in increased access to primary and secondary levels of education, the opposite has happened at the tertiary level. The tertiary level has stagnated while the lower levels have expanded resulting in the denial of access to tertiary level education to many.

Enrolments in IDCE courses began to increase more noticeably from 1985. Figure 2.6 below provides an indication of the trend in the rate of increase of enrolments, in distance education courses since 1985. The graph in figure 2.6 clearly shows the increasing demand for places in both the matriculation and tertiary level courses. Statistics post-1993 show that the trends noted, in figure 2.6, continued well into the latter half of the nineteen-nineties. The 1997 IDCE report for instance, shows that the enrolment figures reached well over 15000 in 1996 (IDCE Report, 1997). Clearly, this attests to the unfulfilled demand for educational opportunities that exist in the country.

*Figure 2.6: Extension Studies Enrolment Trends from 1985 to 1993*




The 1990 and 2000 national censuses, as briefly discussed in section *, provide a rather gloomy picture that the situation may actually get worse rather than better. The population, going by current trends, will be around 7.5 million by the year 2015 (Census, 2000) and this will result in enormous pressures on the various governmental services including education.

The following is an excerpt from a report titled "Public Outreach in Higher Education in Papua New Guinea" by the former director of IDCE, Professor Markowitz, presented at a PNG ministerial summit in 1995 (Markowitz, 1995):

> Throughout the developing world, a rising demand for education has been created by unprecedented population increases. As one of the fastest growing nations in the region, PNG is heavily influenced by its proportion of youth to

> adults. Provision for mass education is just one of the policy decisions that must flow from this reality, but it is a pressing requirement. Since it is unlikely that schools can be built or teachers trained with the same speed the population is growing, alternatives must be found.

Another phenomenon that highlights the unfulfilled demand for educational opportunities is the unprecedented growth of private fee-paying institutions, some of which are charging exorbitant fees for sub-standard courses. There were also other more substantial examples of private institution growth as the result of unsatisfied demand for public school places. One of the more outstanding examples of the private sector response to demand for school places is Port Moresby Grammar School, which began in 1992 and now has enrolments of more than 1000 students. In the professional education sector, especially in commerce, the privately owned and run Institute of Business Studies (IBS) is developing a reputation as a good alternative to public-funded and run Institutions. Together with these two institutions are other less reputable private enterprises with varying degrees of success.

Both the institutions mentioned above as well as others run IDCE courses under agreement. Many other institutions are also clamouring for the right to offer IDCE courses under arrangements similar to those with Port Moresby Grammar School and IBS.

All of the institutions that are running IDCE courses are doing so in various mixes of distance and face-to-face modes. In general these institutions are using the distance education materials produced by IDCE to teach their students full-time face-to-face.

The quote above by Markowotz (1995) identifies one of the main reasons for the espousal of distance education in Papua New Guinea - the potential of distance education for facilitating mass education.

Guthrie (1991) touched on another reason for the attraction of distance education in Papua New Guinea and other South Pacific countries other than Australia and New Zealand:

> All countries have small population numbers, often at low densities, and some have these populations spread over very far distances. Add shortages of finance and of trained educationists, particularly at higher levels of the

education systems, and the advantage of centralising training facilities in distance units appear obvious.

Van Trease (1991) also noted the potential of distance education in PNG:

The physical nature of the country with scattered centres of population (19 provinces plus the National Capital District) and problems of transport make learning at a distance the only option for many of PNG's nearly four million people.

Crossley and Guy (1991) noted that cost-effectiveness and improved access to educational opportunities were two factors that made distance education attractive amongst the decision-makers in PNG.

### 2.11.2 Issues of Cost

The previous section noted briefly the issue of cost-effectiveness of distance education. While distance education for large numbers of students may be cost-effective, the all-up costs of text-based distance education in PNG, as is presently the case, is still prohibitive. One can quickly get a picture of the enormity that issues of cost assume in distance education in Papua New Guinea from the topology of the network of University Centres (see figure 2.1). The bigger red squares on the map of Papua New Guinea in figure 2.1 indicate the location of University Centres. There are 16 formally established University Centres, each with its own sub-centres. Not all of them were operational at the time of writing. The cost of distribution of materials alone, given the scatter of the network, is prohibitive.

Other cost factors are the printing of materials and tutorial assistance for the students in each subject, although the minimal fees charged each student for each course enrolled in covers this cost.

### 2.11.3 Pedagogical and Cultural Issues

Other problems distance education in Papua New Guinea faces are:

1. *That currently the courses on offer are very much text-based supplemented with a limited amount of face-to-face tutorials.*

Guy (1990) for instance noted this as a possible drawback to Papua New Guinean learners in highlighting the problem of text in schools as well as in distance education. He saw text as technocratic, meaning that this focuses on the elements of control, prediction and certainty. He wrote:

> The discourse is regulated by the materials and the institution and the course writer has control over the definition and selection of knowledge, even to the extent of supplying model answers (Guy, 1990)

Guy also noted the heavily skewed power relations in teaching in PNG where the student is a passive, powerless participant in contrast to the all-powerful teacher, a situation that may not be altogether conducive to optimum learning for the student.

This observation reflects the prevalence of the behaviourist approach in the design of distance education instructional materials, in PNG. The investigations in the present study, attempts a move away from the structured-behaviourist approach to learning to a more flexible-constructivist approach.

2. *That the exclusively text-based form of PNG distance education may in fact be impacting negatively on Papua New Guinean learners. It forces them to adopt a learning style, i.e. text-based, which is alien to the traditional style of oral instruction i.e. face-to-face instruction and group learning situations.*

In Papua New Guinea and in other traditional societies the history of reading, writing, and written instruction is rather short. There is therefore little tradition for text-based modes of learning to use as a springboard to learning.

3. *That distance education strongly promotes an individualistic approach to learning.*

Holtzmann (1975) and Perraton (1979) noted that learning styles of many developing world societies were often group oriented. Using the notions of collectivism and individualism from the field of social psychology (Triandis, 1995), Guy [, 1989] noted that people from traditional cultures in the developing world were more collectivistic in orientation in contrast to people in the developed world. This poses the question, whether Papua New Guineans are culturally well disposed towards the paradigm of learning at a distance, which underlies the practice of distance education.

This point appears to be counter to the aims of the present study, which amongst other objectives is to investigate the potential for a more individualised approach to instruction in distance education using modern computer-based educational technologies. However, it is argued that a computer-based learning system can cater for both a collectivistic and individualistic approach to learning. There is also the possibility that computer-based interactive software may somewhat compensate for this drawback.

4. *Learners in Papua New Guinea may see the lack of presence of an instructor in a distance education situation as a disadvantage.*

Markowitz [, 1994] noted the problem that the lack of physical presence of a human instructor poses for the Papua New Guinean learner. Thaman (1996) also alluded to the problem that lack of presence poses in the distance education situation, in the wider context of traditional societies in the South Pacific Islands.

> ... the notion of a learner who is independent of a teacher was, and perhaps still is, a difficult one for many Pacific Island peoples to appreciate. At the USP, we have found that most of our students will continue to require personal contact with tutors, despite attempts to make course materials completely 'standalone'.

The fact that all distance education courses offered by IDCE have two hours of tutorials per week programmed into them, where number of enrolments make it economical to hire a tutor, was a recognition of this problem. It was also in a way, recognition of the limitation of text as the sole media of instruction in the PNG context. Unfortunately, the tutorial arrangements only benefit those who live near University Centres or Sub-centres many others have to rely solely on texts.

## 2.12 Distance Education in PNG

### 2.12.1 The College of Distance Education (CODE)

The introduction of Distance Education in PNG closely followed the introduction of the formal education system in 1946 with the establishment of the correspondence school in 1952. The establishment of the Correspondence School in 1952, which became the School of External Studies in 1967, was the forerunner of Distance Education in Papua New Guinea (Markowitz, 1994). In 1959, this school had an enrolment of 800 students and 22,000 enrolments in 1972. In 1978 the name of the school was changed again to the College of External Studies and is now known as the College of Distance Education (CODE) having undergone yet another name change in 1988 according to Kema and Guy (1991).

The establishment of CODE was recognition by the authorities of the lack of educational resources to cater for every school-aged child. CODE focuses on the grades 7 to 10 levels of a general education as well as a certificate course in commerce. It has plans to develop courses for grades 11 and 12. At present, IDCE is offering Grade 11 and 12 equivalent courses, with plans to discontinue this in the near future. This practice is a hangover from the days when UPNG offered a preliminary year of study before enrolling in University courses.

Kema and Guy (1991) noted that the enrolment for CODE reached 27,780 in 1990 and around 45000 in 1993 (Markowitz, 1994). This placed an enormous burden on the College because it did not have the resources to cater for such large numbers of enrolment. The large numbers of students enrolling with CODE is a clear indication of the many school-aged children not being absorbed into the formal education system and the desire for educational opportunities by many parents and children.

### 2.12.2 The Institute of Distance and Continuing Education (IDCE)

A tertiary level equivalent of the Correspondence School was not established until 1975/76 with the establishment of Extension Studies at the University of Papua New Guinea now administered by the Institute of Distance and Continuing Education (IDCE) since 1994.

According to Van Trease (1991) and Markowitz (1994) the beginnings of distance education at the University of Papua New Guinea is traceable to the Currie Commission of 1964. The Currie Commission resulted in the establishment of the University of Papua New Guinea. The UPNG charter included external teaching as one of the five objectives of the University.

Ten years later a more detailed report known as the 'Report of the Committee of Enquiry into University Development', otherwise known as the 'Gris Report' of 1974, cited at the beginning of the present chapter, was commissioned. This report set out amongst other things the need for University Centres in the Provinces of Papua New Guinea as part of the University's outreach program.

Distance education at UPNG took on a more definitive role in 1975, with the appointment of a director for External Studies. In 1976, External Studies introduced its first external offerings. By 1978, the number of full-time, permanent staff stood at four including the director. There was also a number of full-time temporary staff hired to write courses and coordinate special projects. In 1980, UPNG established the Extension Studies Department followed soon after, in 1981, by the appointment of the first director of extension studies at a professorial level. The first University Centres of North Solomons, East New Britain and Madang were established not long after (Van Trease, 1991).

In 1994, following changes in the structure and operations of the Faculty of Education at UPNG, the Extension Studies Department became the Institute of Distance and Continuing Education (IDCE).

The following sets out "The Mission in Brief" of IDCE.

> Our mission is to bring the University to the people. We provide outreach programs of assured quality to meet the changing needs of the nation. To do this the Institute shall:
>
> - Coordinate the distance teaching of the University departments
> - Offer the "second chance" of a matriculation program
> - Administer University Centres in all provinces
> - Prepare and offer distance education courses at all levels
> - Operate a continuing education program
> - Conduct appropriate research

While there are other providers of distance education services, in terms of sheer numbers of enrolment CODE and IDCE are by far the major players in PNG distance education. The Papua New Guinea University of Technology (Unitech) in Lae for instance only began providing distance education services in 1994 (Markowitz, 1993) and Pacific Adventist University commenced its distance program beginning 1985 (Meintjes, 1991).

### 2.12.3 System of University Centres Operated by IDCE

UPNG operates a system of University Centres in a 50-50 partnership with various provincial governments. Although there are 20 provinces including the National Capital District, there are only 16 University centres altogether. Figure 1.1 (page 13) shows the scatter and locations of the 16 University Centres in the country.

The University Centres were seen as the University of PNG in miniature (Kemelfield, 1991) in the various provinces in which they were established. Unfortunately, the fates of the university centres are bound to the economic performances and fortunes of each province. This accounts for the fact that not every province has a University Centre and, of the 16 officially established ones, not all of them are operational at present.

### 2.12.4 A summary of current practices in IDCE

Courses are at present offered in three areas: review courses, high school courses leading to a Certificate, and university level courses which lead to certificates and diplomas. Though numerous program options and variations exist for part time students, the six programs that at present account for most enrolments are:

1. The Pre-Matriculation Program, which offers review courses in mathematics and English but, does not lead to a certificate.
2. The Matriculation Program, which permits students who complete grade 10 to finish grade 12.
3. The Diploma in Teaching (Primary), which permits those who have completed a recognized teacher training course to complete a combination of matriculation and degree courses for a teaching credential.

4. The Bachelor of Education (In-Service) accepts matriculated students and permits them to complete their degrees through a combination of distance education and residential study.
5. The Diploma in Commerce, which accepts those who have completed a matriculation program or equivalent. This has at present only one area of concentration, in accounting. Students who complete a Diploma in Commerce with a C average or better may apply for full time study in the UPNG Bachelor of Arts (Commerce) program.

Individuals may enrol in one course or a few courses to develop skills in a subject area without having to declare that they are pursuing a stated program of study. These students are required to meet the same entrance requirements as others in the courses.

The adult matriculation program is the alternative way of gaining university entrance status for those who do not have Higher School Certificate (HSC), that is grade 12 results as entry qualifications to tertiary education in Papua New Guinea. The program consists of eight courses in a choice of one of two streams: the two streams being the science stream and the social science/economics stream. The adult matriculation program requires the student to complete eight semester-long courses, with a mandatory two semesters of English, 2 of Mathematics and the generalist 1 semester course, History of Science and Technology. Those in the arts concentration may then choose three additional courses from social science. Science concentration students must take specified science courses after the mandatory courses.

The Diploma in Teaching (Primary) program requires the student to take twelve courses, starting with four matriculation subjects. The student must then take eight, degree-level courses from a specified list.

The Bachelor of Education (In-service) program requires a recognized teacher credential for entry. Students then complete degree-level courses equivalent to an additional two years of full time study. Variations in each person's program reflect his or her career interests.

The Diploma in Commerce consists of two parts. Part 1 leads to the Certificate in Commerce and requires completion of nine degree level courses: Seven other courses are required for completion of the Diploma in Commerce external program, two of these being yearlong studies. The whole Diploma program, which takes two years of full-time study to complete, will normally take about four years of part-time study.

### 2.12.5 Constraints on the development of distance education in PNG

Constraints on the development of distance education in Papua New Guinea are numerous. Previous sections have dealt with some of these. Others include the lack of formal schooling on the part of a significant proportion of the population, the absence of utilities such as electricity outside the urban centres and the limited number of women students who complete grade 10. Because of these and other characteristics of the population and the nation, the distance education program in PNG has educational goals that are more modest.

The mode of instruction for all subjects usually involve the use of tutors meeting with students on a two hours per week basis, though attendance at these tutorials is not compulsory. Courses offered at each centre are selected from a list of courses available to all centres, but tutorial groups generally are offered only if there is enough demand to form a class. Each centre coordinates the activities of one or more sub-centres, and each forms study groups to permit academic work in isolated areas. In provinces without centres, informal centres and study groups often exist, and isolated students are permitted to enroll as 'outstation students' studying in the correspondence mode.

## 2.13 Conclusion

School education in PNG even today has a number of highly competitive selection points. Thus the large majority of school-aged students have no chance of completing grade 12. Selection into University is, again, highly competitive and many of the small proportion who complete grade 12 cannot gain entry. A further complicating factor is that while the education reform that began in 1993 expanded enrolments at the primary and secondary school levels, no corresponding expansion has taken place at the tertiary level. Unfortunately no future expansion of tertiary places is envisaged hence the recent push towards an expansion facilitated by computer-based distance education. For these and many other geographic reasons distance education is significant in PNG, and extension and continuing education is increasingly in demand.

The next chapter (chapter 3) discusses the area of computer-mediated communications (CMC) in educational technology and its relevance in distance education. In particular the discussion concentrates on the specific area of CAI or CAL in computer-mediated communications and its use in distance education. The first half of the chapter provides some definitions of CMC and CAI or CAL and what they involve.

A literature review is presented in the second half of the chapter on instances of how CAI has been used before in education and distance education, in other countries. The literature review is focussed on studies on the effectiveness of CAI or CAL in mediating teaching and learning.

# Chapter 3: Computer-based Educational Technologies – a Review of Literature

## 3.1 Introduction

This chapter discusses computer-assisted instruction (CAI) together with all other synonyms of CAI, under the general category of educational technologies known as computer-mediated communications or CMC. This discussion provides a context for the aims of the present study in investigating alternative, non-traditional teaching and learning media, particularly in a distance education context in PNG as noted in the conclusion of chapter 2.

CMC covers an extensive class of computer-based communications technologies increasingly in use in distance education to bridge the 'distance' and 'time' factors in distance education. Zorkoczy (1989) observed that the most notable contribution of CMC to distance education was in diminishing the constraints of time and space imposed by the physical separation of tutor and learner by providing more attractive means for 'closing the loop'.

This chapter discusses various aspects of CMC and attempts to establish an argument for the relevance of the media in the PNG education context, which is inclusive of distance education. The focus of the discussions in the chapter is on the aspect of CMC that is collectively known as either computer-assisted instruction (CAI) or computer-assisted learning (CAL). To avoid wordiness, the acronym, CAI, is used to refer to all relevant CMC-based functions such as CAI, CAL and CBI in the present thesis. Section 3.4 below provides a brief consideration of the various acronyms that abound in the field of computer-based educational technology, with brief explanations of the terms and their usage in the relevant literature.

CMC, as it becomes apparent very quickly, covers a large and rapidly expanding field of technology. The following discussion is therefore of necessity limited in scope to only the aspects of CMC relevant to the context of the present study and PNG education, especially distance education. In particular the discussion focuses on the CAI aspect of CMC.

The second part of the chapter presents a literature review of CAI use in various settings, with reference to specific studies in CAI use in the teaching of mathematics. The specific studies in a summary table form (see section 3.12.4) show the effect of CAI-based mathematics teaching on students. The implications of the results in the cited studies form a backdrop for the future development of CAI in mediating instruction in mathematics in PNG.

The initial sections of the chapter discuss the connection between distance education and CMC both in a general context as well as in a PNG national context.

## 3.2 A Distance Education Context for CMC

### 3.2.1 The general context

The hallmark of distance education, as acknowledged by all definitions of distance education, is education that is taking place while there is separation between the teacher and the student by space and time. Despite the existence of distance education for some time now, there is still the dominating assumption, whether rightly or wrongly, that face-to-face interaction between the instructor and the student is the optimum situation in effective teaching and learning. Based on this assumption there has been much searching for ways to achieve this ideal without losing the advantages of distance education.

The rapid advances in educational technology have provided the most effective means for achieving this ideal without the loss of the advantages that distance education affords. Various aspects of CMC facilitate effective interaction between instructor and student separated by time and space. Many CMC functions facilitate a near face-to-face experience in teaching and learning while the teacher and student remain separated by physical distance. Computer-based video conferencing, for instance, can facilitate 'different-place-same-time' experiences in instruction.

Some, for example Mason and Kaye (1990), have gone as far as claiming that learners participate and interact more in computer conferencing (CC) than in face-to-face environments. Walther (1992) observed that regardless of the absence of social presence in CC leading to less personal and socio-emotional interactions, CC often supports more task-oriented communication than face-to-face communication. A similar study by Jonassen and Kwon (2001) support these conclusions.

Dede (1996: p. 5), in a position paper on the emerging technologies in distance education, had this to say on the question of what the evolution of new media meant for distance education:

> A medium is in part a channel for conveying content; new media such as the Internet mean that we can readily reach wider, more diverse audiences. Just as important, however, is the idea that a medium is a representational "container" enabling new types of messages (e.g., sometimes a picture is worth a thousand words). Since the process of thinking is based on representations such as language and imagery, the process of learning is strongly shaped by the types of instructional messages we can exchange with students.

The present thesis focuses more on CMC in the sense of a "representational 'container' enabling new types of messages". The possibilities for combining in innovative ways these 'new types of messages' has widened and developed considerably over the last decade and continues to evolve. CAI is the significant aspect of CMC that enables the new types of messages. Section 3.8 discusses multimedia CD-ROM, one of the facilitating, computer-based technologies that enable the 'representational container' qualities of CMC, enabling the 'new types of messages'.

### 3.2.2 The PNG Distance Education Context

As noted earlier, the most notable contribution of CMC to distance education is in diminishing the constraints of time and space inherent to distance education by providing more attractive means for 'closing the loop' (Zorkoczy, 1989). This addresses the three drawbacks inherent to the distance mode of study for PNG students noted in the following paragraphs.

One of the perceived major drawbacks of distance education noted in chapter 2, in the view of some, is the lack of face-to-face contact between the instructor and the student. Markowitz (1994) alluded to this view, held by many in PNG, that distance education is a 'shadow form' of traditional (classroom-based, face-to-face) education. This view is based on the assumption that there should be face-to-face contact between tutor and student, if possible, for effective learning to occur. He suggests that the limitations imposed by this view in time, space and cost expunges some of the advantages of distance education. He goes on to say that the view of distance education as a 'shadow form' of traditional education has been a dominating assumption in Papua New Guinea and has acted negatively on the development of distance education in the country.

Another drawback is the one noted by Guy (1990) of the perception of text as central to distance study. This perception is problematic from the standpoint that Papua New Guineans have a long oral tradition but lack the discipline of a written one, which is central to text. Given this cultural history in Papua New Guinea, it is somewhat surprising that very little attempt has been made up to this point to provide for learning at a distance using approaches other than printed materials. The perennial shortage of resources is partly to blame, although not entirely.

A third drawback is the decidedly behaviourist orientation of distance education course design in PNG. In view of the more recent prominence of constructivist notions of teaching and learning this is also a significant drawback.

The obvious and significant question that follows then is: how can distance education providers in Papua New Guinea overcome these three substantial drawbacks in traditional distance education and still provide a real alternative in quality education by distance mode?

There is no simple and clear-cut answer to this question. The main route that many distance education programs are taking, particularly in the developed world, is the path of technology. The researcher adopts this path in the investigations conducted in the present study.

There are many different types of technologies in use in education today. In the context of the present study however, it is necessary only to look at a class of communications technologies commonly known as computer-mediated communications or CMC for short. Even this much narrower focus on educational technology is still too wide in the context of the present study; hence this review focuses on the aspect of CMC known as CAI.

An attempt at a more formal definition of CMC and CAI appears in section 3.4. The following subsection establishes some arguments for the adoption of a CMC-based distance education in PNG and considers the question, "How can CMC in the form of CAI in particular advance the cause of distance education in the PNG context?"

### 3.2.3 The Suitability of CMC in the PNG Context

In the context of the present study the two main factors that make CMC particularly suitable to the PNG situation are:

1. The scattered centres of population and the consequential transport problems (Van Trease, 1991) that are the natural consequences of the geography of the country.
2. The oral traditions of Papua New Guineans where text as the predominant mode of teaching is inadequate.

The Internet has the potential to address the first factor while the interactive and multimedia nature of computer-based learning programs has the potential to address the second factor. The Internet addresses the challenge of 'distance' in distance education, breaking down barriers imposed by geography. There are many reasons why people cannot travel from their normal place of domicile to where learning institutions are located. There is the cost, both initial as well as continuing, of education in terms of fees as well as other costs. Discontinuing paid employment in order to take up studies may not be advisable for reasons such as being the sole family breadwinner. Then there are domestic situations (for women especially) that make it impossible to take up full-time studies. CMC and the Internet can overcome some of these natural barriers.

Computer-based teaching and learning such as that provided by CAI can provide a more 'hands on' experience. Balacheff and Kaput (1996), writing in a mathematical context, labelled it " a new experiential mathematical realism". This contrasts to text-based teaching and learning, especially where face-to-face tutorial help is not available. Becker (2000) noted that students' attention, effort, and engagement in academic tasks is a critical intervening variable in determining whether instruction outcomes are attained. Computer-based learning activities enhance student engagement on academic tasks by providing an intellectual challenge, motivating students and stimulating student curiosity (Lepper, 1985).

Although these observations are from other countries, they could well be applicable to PNG students. Given that Papua New Guineans have a very strong oral tradition as opposed to a written one, CAI has the potential to cater more effectively to their cultural orientations through the 'experiential realism' possible through CAI.

More recently, due to the number of places in tertiary education in PNG remaining static as the primary and secondary sectors expanded, a third factor makes the adoption of CMC imperative in the PNG education context. As noted in chapter 1 the universities are increasingly looking at computer-based distance education to make tertiary education accessible to a greater number of students. Both the Internet and computer-based modes of teaching and learning, such as CAI, are capable of mediating learning at a distance in expanding tertiary education.

Due to the wide scope of the field of CMC, a narrowing-down of focus for the present study is necessary. To that end therefore, the present study zeros in on the 'computer-based-learning-programs' aspects of CMC, namely computer-assisted instruction (CAI).

The next section looks at some of the advantages and disadvantages of adopting CMC in the form of CAI to mediate distance education, especially in the PNG context.

## 3.3 CAI-mediated Education: Advantages and Disadvantages

### 3.3.1 The Advantages of CAI

The following is a list of some of the factors that educational technologists see as advantages of CAI-based systems of teaching and learning. In distance education, the comparison is often with text-based instructional delivery, as well as contrasting it to face-to-face instruction.

CAI can:

1. Facilitate interactivity
2. Facilitate immediate feedback
3. Facilitate realistic audio effects
4. Motivate students by providing better visual effects – Colour and animation
5. Facilitate individualised (self-paced) learning
6. Facilitate Simulation

Subsections 3.3.1.1 to 3.3.1.6 discuss a theoretical basis for some of the advantages of CAI listed here.

Lauzon and Moore (1989: p.39), for instance, noted that the advantages of CAI include:

> Individualized instruction and self-pacing, allowing instructors to effectively deal with a diversity of backgrounds; self-assessment, diagnosis of problem areas and reference to appropriate materials; provision of drill and practice exercises to facilitate the memorization of factual material; frequent updating of factual materials; facilitating students' perceptions that learning is an active and dynamic process.

According to Garrison (1987b) CAL or CAI allows the learner to control and pace the learning thus providing for the diverse needs and characteristics of adult learners in a safe and secure environment.

Much CAI research is from the 70s, well before the real information revolution began in the early 80s with the arrival of the PC. Early CAI was often no more than computer-based reincarnations of text-based lecture notes and required as good a reading ability as in text-based courses. Many criticisms of CAI often refer to these early examples of CAI. As Stolurow (1968) notes, even then there was a clear recognition of the potential of CAI in mediating learning.

With improved technology and better programming software, CAI provides for audio-visual effects e.g. graphics, talking heads, pictures, animation, audio, interactivity and the like which were not available in the early days of CAI. The effectiveness of interactive computer-based instruction is observed not only in mathematics but also in areas such as in writing instruction (Parr, 1996; M. W. Reed, 1996), social studies (Berson, 1996) and science (Nicholls, Merkel & Cordts (1996)).

The following subsections discuss briefly some factors that CAI is often associated with improving.

#### 3.3.1.1 Interactivity

Interactivity is an important concept in teaching and learning, especially in computer-based instruction and learning environments. The following briefly considers interactivity in the context of computer-based teaching and learning.

Ellington et al (1993) included "learning by doing (practice, trial and error, experimentation)" or "interactivity" as one of the four essential processes which accompany successful learning.

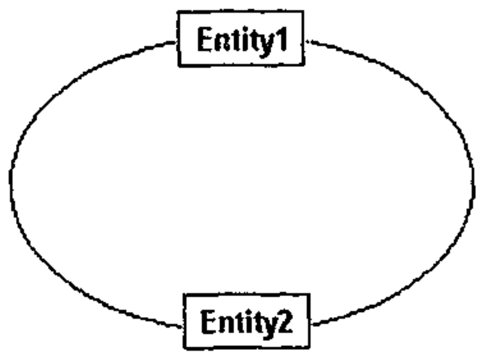
Berge (1999) observed that although there is a view that a high level of interaction is desirable and positively affects the effectiveness, it is not clear from research or evaluation data that interaction improves distance education.

Yacci (2000) in attempting to provide a definition of interactivity proposed four major attributes to the concept of interactivity:

1. Interactivity is a message loop
2. Instructional interactivity occurs from the learner's point of view and does not occur until a message loop from and back to the student has been completed
3. Instructional interactivity has two distinct classes of outputs: content learning and affective benefits.
4. Messages in an interaction must be mutually coherent.

The figure below illustrates this message loop between two entities that are interacting.

*Figure 3.1: The Instructional Message Loop between two Entities Comprising an Interaction (adapted from figure 1, Yacci, 2000)*




According to Yacci "entities in an interactive loop can be students, instructors, computers and others capable of receiving and sending messages" (p. 6). Berge (1999: p. 6) describes interaction in a distance education setting as follows:

> Interaction is two-way communication among two or more people within a learning context, with the purposes either task/instructional completion or social relationship-building, that includes a means for teacher and learner to receive feedback and for adaptation to occur based upon information and activities with which the participants are engaged.

Flottemesch (2000) noted that in a distance education setting interactivity can provide a means to motivate and stimulate learners using means which include technology. Technology serves to influence the types and amounts of interactions and affects students' perceptions of the class and the communication in it. According to Pierol (1996: p. D2), "the most effective computer assisted learning...transfers the power to students by giving them virtually limitless access to information and allowing them to process it on their own". Goldman (1996) noted that interaction in a resource-rich computer environment supported increased participation of students in classroom conversations about science concepts. This was in contrast to the level of participation in a more traditional teacher-centred, lecture-demonstration environment.

Counter-balancing these rather optimistic views of interactivity is caution about simplistic assumptions that it is a panacea for education (Aldrich, Rogers and Scaife (1998)). While there seems to be quite a volume of research showing the effectiveness of interactive computer instruction it is probably a more accurate reflection of research conclusions in these areas to say that the results are mixed. Clark (1984), in reviewing research on CAI, highlights the other side of the argument. He states that existing evidence indicates that computers do not yield learning benefits and that evidence that shows otherwise is subject to compelling rival hypotheses concerning novelty effects and instructional method/content effects on learning.

Most definitions of interaction assume, even if not explicitly stated that interactivity in instruction must occur from the student's point of view. Rose (1999) termed this "learner control of an information-rich environment". She concludes from reviewing literature that this is the defining trait of interactivity.

A cautionary note on the use of the terms "interactive" and "interactivity" concludes this brief section. Often people attribute "interactive" and "interactivity" to teaching media which are not. Indiscriminate use of the terms to describe any new advancement in instructional technology has resulted in some confusion on the concepts of interaction in the teaching/learning situation (Rose, 1999). The four syllables, 'in-ter-act-ive' have even been likened to "the jangle of loose change in the marketing man's highly sensitive ears" (Sargent, 1997), as a reflection of market driven over-use and in some case abuse of the term. These observations lead to the conclusion that there is some ambiguity that remain with the use of the concept of interactivity.

These cautionary sentiments notwithstanding, CAI and other computer-based learning media provide a vast potential for implementing interactivity in learning, especially in distance education where text-based learning is inadequate.

#### 3.3.1.2 Motivation

The importance of motivation in the teaching and learning environment cannot be over-stressed. It is an essential ingredient for cognitive learning. Weiner (1979) documented the importance of motivation to the constructivist learning paradigm. Motivation is necessary to facilitate engagement in cognitive processes.

Ellington et al (1993) for instance included "wanting to learn" or motivation as one of the four essential processes which accompany successful learning. In the case of CAI, this implies stimulating visual imagery and color. The effects of colour on learning in the CAI environment rates a mention here only as far as it enhances motivation creating visual appeal for the CAI-mediated lessons.

While it is true that some of the motivation in CAI-mediated teaching and learning is due to the novelty of the computer-based medium, which eventually wears off (Clark, 1983), there are other factors that can make learning through CAI continue to be appealing. For instance, Relan (1992) noted that "the cumulative effects of entities such as color, graphics, and animation is recognized as instructionally and motivationally powerful".

#### 3.3.1.3 Animation

Animation as a variable in the learning process is discussed separately here because there have been some studies investigating the effect of animation on learning effectiveness through CAI. Rieber (1990) comments, "although the use of animated visuals is both common and popular among CBI designers, the theoretical and empirical foundations of their use have not been firmly established"(p. 77). Generally, the use of animation in instruction fulfills three functions: attention gaining, presentation, and practice.

Recent CAI and Internet software show liberal use of animated visuals, which lead to questions such as the following. Is animation effective as a learning device? Are there research data to support the effectiveness or otherwise of animation?

According to Rieber (1990) most animation studies are based on conclusions from research on static visuals and often are extensions to such studies. He summarised the prevailing conclusions from studies on static visuals as follows:

1. Pictures are superior over words for recall tasks
2. Adding pictures to prose learning facilitates learning assuming that the pictures are congruent to the learning task
3. Children up to about the age of 9 or 10 rely more heavily on externally provided pictures than older children
4. Children do not automatically or spontaneously form mental images when reading

Additionally Rieber noted that dependence on picture decreases with age because older people are better able to produce their own mental images.

Studies on animation are few and have produced mixed results with some studies showing effectiveness with learners with low spatial abilities on short-term and long-term comprehension (Hays, 1996; Milheim, 1993; Rieber, 1990). Hays (1996: p. 140) notes "that for understanding events such as those with three-dimensional objects moving in time and space, lower spatial ability people would benefit from some form of visual assistance to make the same gains in understanding as those with higher spatial abilities".

He noted further that higher-spatial ability people have no problems in easily creating and manipulating representations of events mentally without the need for animations.

Although no specific research data is cited here, this researcher, as a student and then a teacher in the PNG education system, has often heard discussions concerning the perceived low spatial abilities of PNG students. Expatriate teachers, particularly from industrialised countries with experience teaching students from their home countries, frequently made these observations. Often these comments are in association with students' performances in mathematical tasks involving the mental visualisation and manipulation of multi-dimensional objects.

Thus, the observation on computer-based animation improving spatial abilities of students could well be relevant in the PNG education context. If animation does significantly improve students' spatial abilities then animation as facilitated by CAI could well be beneficial to PNG students.

Computer-based learning applications such as CAI are the only media that enable animation as envisaged in the present thesis. In fact Rieber (1990) went as far as to comment that "interactive dynamics demonstrate a use of animation not easily replicated with media other than the computer" (p.78).

Given the mixed results of research on animation in CAI, some, e.g. Milheim (1993), have devised guidelines in the creation of animation that err on the side of caution. The guidelines advise simple and short animations accompanied by a short narration rather than complicated ones, animations that clarify, and the use of animated prompts e.g. colour, sound and other cueing strategies.

Rieber (1990) pointed out that often animation is used with the intention to impress rather than to teach. He noted that sound and graphics are seductive features of new technologies, which explains to some extent why they are so popular with Internet and software developers. He advises to keep in mind the following, in designing animated visuals in instruction:

1. Animation should be incorporated only when its attributes are congruent to the learning task
2. Evidence suggests that when learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animation
3. Animation's greatest contributions to CBI may lie in interactive graphic applications (e.g., interactive dynamics)

With newer and better computer-graphics software, and the vastly increased processing power of computers, it has become increasingly easier to create 3D animation on computer screens. Graphics as used here refer to the representation of any object, concept or process visually, that is not exclusively dependent on numbers or text. Based on this definition, animation is simply a series of graphics that change over time and space.

Szabo and Poohkay (1996) conducted an experimental study on the effectiveness of computer animation, as an aid to learning. In this experiment, one hundred and seventy four elementary education majors at the University of Alberta were randomly separated into three instructional groups of high and low achievement levels in mathematics based on a pretest. The test, which was designed to measure ability in constructing triangles and identifying trigonometric concepts, showed a 21% and 35 % higher achievement than the graphics and text group, respectively. This suggests that animation is more effective as an instructional tool compared to static graphics and vastly more effective than text-only instruction.

In terms of the experience of PNG distance education students, this is a very important point to note, as all distance education materials to date are text-based. The results noted in the study quoted above begs the question, would the learning experiences of PNG distance education students be enhanced significantly, if computer-based animation in course presentation is incorporated?

Szabo and Poohkay (1996) also noted the attitude of the students towards these three different forms of CAI. They found that students had a more positive attitude towards the animation and graphics forms of presentation than the text-only form. They concluded in the study "that when animation is used to present content and is directly related to the objectives of learning substantial gains in learning is possible, and students like it better than textual presentations". This ties back to the point by Rieber (1990) noted earlier that animation should be incorporated only when its attributes are congruent to the learning task.

While the study cited above seemed to have been effective in showing the advantages of using computer animation in instruction the theoretical basis as to why animation seems to be more effective than text-only instruction is very thin in the study. Siliauskas (1986) in attempting to provide an explanation on such observations proposed that the interactive aspects of graphics may be the reason for the effectiveness of animation as an instructional tool. Park and Hopkins (1993) proposed an explanation as follows, that animation acts as a cue hence gaining the learner's attention thereby influencing an association between the verbal and visual components of the task. This, admittedly is a behaviourist explanation of the observations.

Whatever the actual reasons may be, the observation touches on the interactive aspects of computer-based learning discussed in section 3.3.1.1, that interaction with the media of instruction could well be a very important condition for optimum learning to occur. Animation promotes the interactive aspects of CAI software.

In summary the focus in the development of animated visuals must be on the needs of the learner, with the demands of the learning task determining when and where, animation is necessary. Animation, as the few studies seem to suggest, is an important enhancement of CAI software and improves its effectiveness even if a complete explanation of the reasons for its effectiveness are still in the future.

#### 3.3.1.4 Feedback

Besides "learning by doing (practice, trial and error, experimentation)" or "interactivity" in the CAI sense, and motivation, Ellington et al. (1993) also included "feed-back" from other people (trainers, teachers, colleagues, anyone!) as one of the four essential processes which accompany successful learning. Feedback, which only makes sense from the point of view of the learner in CAI mediated teaching, is the response that the computer generates to the learner's queries i.e. information presented to the student after some input. The feedback may take forms such as text messages and graphic illustrations (Fook and Kong (2001)). Feedback promotes learning during instruction by providing students with information about their performance.

The concept of feedback is not new, having been used in Skinnerian principles of psychology (Price, 1991: p. 23) in the design of instruction, associated with the idea of reinforcement. The new understanding of feedback though is in terms of providing information to the learner about the accuracy of response and level of understanding (Ross and Morrison (1991)). This new understanding has resulted from computer-based learning processes.

Feedback is closely associated with the idea of interactivity in the learning process discussed in section 3.3.1.1 and could well have been included as part of that discussion. Again as noted with interactivity, motivation, animation, colour and sound, CAI and other computer-based media have shown a high facilitative potential to effect feedback.

#### 3.3.1.5 Self-paced Individualised learning

CAI has also shown a high potential to facilitate self-paced, individualised learning to a greater extent than other approaches. As noted earlier, the nature of distance education is such that it encourages and promotes an individualised style of learning. This is because of the isolation of distance learners from other distance learners when they are studying alone at home.

This is not to say that CAI cannot facilitate a group-based and oriented style of learning as well as an individualised style. As noted in an earlier section, some CMC functions can overcome these seeming disadvantages by facilitating different-place-same-time, learning experiences.

Self-paced, individualised learning, characterised as "digesting", was one of the four factors noted by Ellington et al (1993) which accompany successful learning, with the others being interactivity, motivation and feedback. Digesting implies making sense of what has been learned including the feedback received. CAI enables an individualised approach to the process of "digesting".

Akerlind and Trevitt (1999) noted that a core concept in many non-traditional approaches to teaching and learning, such as computer-assisted learning (CAL), is increasing student autonomy. These approaches promote a shift along the continuum from teacher-controlled to learner controlled learning compared to standard lecture-based approaches. They observed that "with computer-facilitated learning in particular, increased independence on the part of the student is often regarded as either a central goal or a desirable side benefit of innovation" (p. 96).

Price (1991: p. 4) notes under self-pacing:

> The computer's capacity for infinite patience allows each learner to progress through the CAI lesson at his or her own pace. The fast learner may zip through a programmed sequence without being held back. Students who experience difficulty can move at a slower pace, review troublesome sections, and request additional practice until the material is mastered. In contrast traditional classroom is group-paced, with all students reviewing the instruction at the same rate.

The above quote summarises succinctly just how CAI can cater for individualised, self-paced learning.

#### 3.3.1.6 Simulation

According to Price (1991: p. 45):

> Simulations constitute one of the most powerful and potentially valuable applications of CAI". CAI simulation programs are designed to represent the essential elements of some real-life or imaginary event or phenomenon without its attendant hazards and inconveniences. (...) simulation programs

enable the user to experience things vicariously that would not be possible or feasible otherwise.

Simulation rates a mention here because it is one of the learning tools that computer-based learning applications are very effective at facilitating. The potential of computer-based applications to enable simulation like no other education media can, make it possible to simulate a real situation with a realistic model or formal representation of some event. Balacheff and Kaput (1996), in noting how computers have provided ways of doing and experiencing mathematics more recently, observed that the "touchstone of these experiences is the experience of direct manipulation of mathematical objects and relations - a new experiential mathematical realism" (p. 470). A brief listing and explanation of some of the specific mathematical experiences referred to appears in section 3.7.2 further on in this chapter.

The possibilities that simulation provides are limitless. Students can simulate on the computer such activities as walking, swimming or a car moving. Students can also simulate a more idealised, schematic and abstract event that represents all objects as points. All of these result in students getting direct mathematical experiences of the real world.

The computer's capability to simulate various physical phenomena outside the traditional laboratory setting in science is also proving powerfully useful. Ronen and Eliahu (2000) report a study in which they used computer-based simulation to simulate electric circuits to a group of 15-year olds. They noted significant differences in the achievements of the two groups in the study with the group exposed to simulation doing better. They noted that the use of simulation enhanced students' confidence and motivation to stay on-task. Simulation provided constructive feedback, helping students to identify and correct their misconceptions and also helped students to cope with the common difficulties of relating the model to real circuits and vice versa.

Short simulation sequences are included in the CAI software developed for the present study. The ideas behind simulation therefore are important in the context of the present study.

### 3.3.2 The Disadvantages of CAI in the PNG Context

One of the major disadvantages of CMC in PNG is the high cost of computer hardware and software. Even with the downward trend in prices for computer hardware in the market today, the cost is still prohibitive for the vast majority of Papua New Guineans. Another disadvantage in the PNG context is the lack of cheap, reliable electricity supply sources in villages, even if computer equipment is available. These problems however, are drawbacks only from the point of view of individual ownership and operation of computer-based technologies, but are not necessarily problems in the context of the present study. As explained in chapter 4, the present study adopts a computer laboratory-based CAI and recommends a computer laboratory-based CAI in implementing the findings of the study.

Many educators have raised very strong and often quite valid objections to the wholesale adoption of technological means as the panacea to access to education. Writing in 1989 Kaye noted that CMC, and by extension CAI, was a relatively new medium in education and ran the risk of being over-promoted like many other new technologies, many of which had failed to live up to their supposed educational potential. CMC technologies in many ways are still relatively new. Campion (1991) asserts that "by treating technology as an independent variable we effectively remove it from our control and by doing so allow it to be perceived as either a monster or a miracle".

In noting some of the forces that push Computer-based educational technologies in the context of developing nations, Bates (1990) wrote:

> Tremendous pressure in the past has been put on developing countries by aid agencies and hardware manufacturers to invest in technology-based projects, but the history of education, particularly in developing countries, is littered with the corpses of technology-based projects that were killed off because of the high operating costs, problems of adaptation to local conditions, lack of skilled personnel to operate the technologies, and lack of effectiveness (p.39).

Syarief and Seligman (cited in Arnold, Shiu & Ellerton (1996: p.704)) highlight this observation when they stated while commenting on efforts to provide hi-tech answers to the problems of increasing participation in junior secondary education in Indonesia:

> Looked at from (the perspective of) a developing country it appears to be a good solution - for somebody else. It is too hi-tech, too expensive and totally inaccessible to the vast majority of children, even if the infrastructure for provision was there (p. 704).

These voices of caution are certainly grounds for some pause for thought before embarking on any CAI projects in a developing country like Papua New Guinea in a significant way. However, they are not excuses for ignoring technology-based means of access to education. Education is such an important social imperative that no means available, computer-based or otherwise, can be ignored.

A necessary starting point in considering the use of CMC and CAI in the distance education context in PNG is to define clearly what these are, the relationship between them, as well as the scope of technologies they cover. The next section attempts to establish the scope and the interrelationships of the various educational technologies under consideration.

## 3.4 Towards a definition of CMC

To the question "what is computer-mediated communication?" the answers somewhat vary. Some even venture the idea that in its widest sense CMC can encompass virtually all computer applications (Santoro, 1995). Kaye (1989) used CMC in its narrower sense as computer applications for direct human-to-human communication to label the following on-line education functions of computers as CMC: electronic mail, computer conferencing and online databases and information banks. According to Zorkoczy (1989), the notion of computer-mediated communication in distance education, while still lacking some precision in meaning, had been evolving along with developments in computer and telecommunications technologies. Ferris (1997) used CMC to refer to "both task-related and interpersonal communication conducted by computer". Ferris included all of the following under CMC: asynchronous communication via email, electronic bulletin board, online chat, use of group software and information manipulation, retrieval and storage through computers and electronic databases. Rapaport (1991), listed bulletin boards, computer conferencing, electronic mail, and information retrieval under CMC.

From the foregoing definitions there does appear to be some consensus on what constitutes CMC. Santoro (1995) in attempting to summarise the various functions of CMC listed the following three broad categories of CMC functions as:

1. *Computer-based conferencing* which involves direct human-human communication
2. *Informatics* were the computer acts as the repository or maintainer of organized information
3. *Computer-assisted instruction (CAI)* where the computer structures and manages both presentation of information and the possible choices available to the human user.

Using Santoro's classification of CMC functions, the following are brief summaries of the three broad functional categories of CMC.

### 3.4.1 Computer-based conferencing

There are three forms of computer-based conferencing. These are electronic mail, conferencing systems and interactive messaging systems. Electronic mail is the most commonly used form of CMC and is a very powerful means of asynchronous communication amongst individuals. Conferencing systems on the other hand are designed to manage group-oriented communications with facilities such as electronic mail exploder systems and bulletin boards. Electronic mail and conferencing systems are all asynchronous modes of communication. Interactive messaging systems on the other hand are synchronous modes of communication. Interactive messaging systems require that all participants are online at the same time in order to engage in a conversation, much like in a telephone conversation except that it is in written form.

### 3.4.2 Informatics

In 'informatics' the computer is programmed to act like an interactive library or online database. Some of the types of services available to users connected to an information system are online databases and campus-wide, information systems. The online retrieval of references from library databases and catalogues such as Monash Voyager, utilised in the creation of the bibliography for the present study, is an example of the 'Informatics' category of CMC.

### 3.4.3 Computer-assisted (aided) instructions (CAI)

Price (1991) used the following definition adapted from the Random House Dictionary to refer to CAI as:

1. the process of teaching by computer
2. the system of individualised instruction that uses a computer program as the learning medium
3. an educational computer program which presents knowledge or skills that can be learned by someone using the computer to run the program.

Other equivalent terms that are used to describe the same class of instructional technologies as CAI are computer-assisted (aided) Learning (CAL) and computer-based instruction (CBI) (Koschman, 1996). Section 3.5 provides a brief consideration of the various acronyms in CMC.

As noted earlier, according to Santoro (1995) CAI is where the computer structures and manages both presentation of information and the possible choices available to the human user. Accordingly, therefore the main idea behind CAI is the systematisation of the instructions to the human user into an algorithmic process i.e. a computer program can be written to enable the computer to interactively deliver the instruction. Price (1991) broadly classified CAI programs as drill-and-practice, tutorial or simulation.

Koschman (1996) referred to CAI as a paradigm in the evaluation and design of instructional technologies amongst other paradigms. Applications in the CAI paradigm included drill and practice programs, which were some of the earliest forms of CAI. Stolurow (1968) identified the following six major instructional modes of CAI: Problem Solving, Drill-and-Practice, Inquiry, Simulation and Gaming, Tutorial Instruction and Author mode.

Santoro (1995) listed the following as the main advantages of CAI courseware:

1. the student is able to learn at his or her own pace
2. reduced dependence on a human instructor

Price (1991) expands on this in listing the following as the main advantages of CAI: self-pacing, active learning, variety, Record-keeping, flexibility and timeliness.

The design of the present study reflected these advantages, particularly as noted by Santoro, that the student is able to learn at his or her own pace and there is a reduced dependence on the human tutor. The two advantages reflect a fundamental paradigmatic shift from the view of the human tutor as the 'sage on stage', to one of being a 'guide on the side' or facilitator. The design also reflects the other aspects of CAI noted in the foregoing sections.

Like all other teaching and learning media there are limits to CAI and Price (1991) noted some of these as, lack of human qualities, restricted text displays, cost, correlation to curriculum and lack of software. Since 1991, vast improvements, both in computer hardware and in software, have been made thus some of the limiting factors noted above while still present are not as limiting as they may have once been.

The next section is a brief note on the use of the various acronyms that abound in the area of computer-based educational technologies. The researcher intends that this will assist the reader in understanding the usage of the acronyms in the context of the present study.

## 3.5 Acronyms in CMC

As briefly noted earlier, there is an abundance of acronyms in use in educational technology in general as well as in CMC. The following is thus a brief consideration of the relevant acronyms in CMC to prevent any confusion that might arise in the use of these acronyms in the present thesis. The following is a list of some of the relevant acronyms; it is by no means an exhaustive one.

CAI Computer-Assisted Instruction or Computer-Aided Instruction

CAL Computer-Assisted Learning or Computer-Aided Learning

CBI Computer-Based Instruction

CBL Computer-Based Learning

CBT Computer-Based Training

CMI Computer-Managed Instruction

CML Computer-Managed Learning

There are many other related acronyms, but in the context of the present thesis, the ones listed here are the most relevant.

While some may insist on precise definitions of these acronyms, the impression of the researcher from the literature that abounds is that these terms are very often interchangeable. For example Burke (1982) stated that the distinction between CMI and CAI is largely one of convention and that from a functional standpoint the two terms can be interchanged. He described CAI as a process in which the computer is actually the prime deliverer of instruction and CMI as a process in which the computer only manages the delivery of instruction.

Jones, Kirkup and Kirkwood (1992) also made the point when distinguishing between CAL and CBL that while there might be a finer definition associated with CAL, CBL is a more general term encompassing both. O'Neil (1981) made the point in relation to the acronym CBI that the term is sufficiently broad to cover a multiple of uses, for example CMI, CAI, and CBT to name a few.

The reader will note that the researcher has used these acronyms interchangeably in line with the perceived broad interchangeability of these acronyms in the literature. This implies that whenever any such terms appear in the text, it is intended to be understood as a general reference to the use of computers in the mediation of teaching and learning. In particular the researcher used the CMC functions of computer-assisted (aided) instruction (CAI), computer-assisted (aided) learning (CAL), computer-based instruction (CBI) and computer-based learning (CBL) interchangeably in the present thesis.

The following section examines how CMC, especially CAI fits into the context of modern cognitive/constructivist thinking in the mediation of learning at a distance. This is particularly in relation to how CAI facilitates student/teacher interactions in comparison to other distance educational media.

How well does CAI facilitate such important roles of teaching and educational interaction at a distance, as pedagogy and constructivist notions of learning? How does CAI affect the cultural up bringing of Papua New Guineans?

The investigation in the present study addresses some of these issues suggesting possible directions for further research.

## 3.6 Immersing CMC in a Contemporary Learning Theory

CMC forms such as CAI is one media out of many that educators in many countries are using to address the inherent problems associated with the paradigm of separation of teacher from student. Distance education invariably imposes this paradigm on the learning situation. The technological means as provided for by CMC is now being used increasingly in developed and developing countries to provide a near face-to-face connection between the instructor and the student. CMC ensures that the distance student keeps the advantages of distance education while receiving tutorial assistance from the instructor in as close to a face-to-face situation as possible.

More importantly, CMC promises to facilitate a cognitive/constructivist approach to learning in distance education that the concept of pre-packaged, non-interactive course materials, which very often were print-based, lacked. The concept of pre-packaged courses in the print-based distance education culture as expounded and developed by early thinking in distance education was perceived as reflecting behavioural orientations (Garrison, 1993), an orientation which has been generally rejected (Holmberg, 1989). Pre-packaged course materials were adopted as the norm in the delivery of distance education in the past to achieve economies of scale (Garrison, 1993), as per the industrial model (Otto Peters, cited in Keegan (1990)). As noted in chapter 2, text may also not be the most appropriate medium of communication in the Papua New Guinean cultural context. Furthermore, course design in PNG distance education, as already noted, is steeped in behaviourist notions of learning.

A new understanding of principles of learning has necessitated a move away from the so-called 'deficit' model of learning (Fowler et al, cited in Young & Marks-Maran (1998)). Each learner needs to negotiate meaning in his or her learning experiences and form his or her own representation of knowledge.

Dalgarno (2001), in writing about changes in accepted learning and teaching practices, noted a shift in psychological and pedagogical theory towards constructivism through three broad principles that define the constructivist view of learning.

1. Each person forms his or her own representation of knowledge
2. Learning occurs when the learner's exploration uncovers an inconsistency between their current knowledge representation and their experience (McInerney & McInerney, 1997)
3. Learning occurs within a social context, and that interaction between the learners and their peers is a necessary part of the learning process (Vygotski*i & Cole, 1978)

Dalgarno notes that while there is broad agreement on the basic tenets of constructivism there are significant disagreements on how to implement the basic principles. Opinions range from the radical constructivism of von Glasersfeld with apparently minimal teacher or facilitator support, to views of knowledge construction occurring within environments of collaboration between learners, their peers, experts in the field and teachers.

Moshman (1982) provides a useful framework in which to relate CAI systems to constructivist notions of learning through the following three interpretations of constructivism.

1. Endogenous constructivism - Emphasis on individual nature of each learner's knowledge construction process (teacher to act as facilitator only)
2. Exogenous Constructivism – Formal instruction, in conjunction with exercises requiring learners to be cognitively active helping learners to

form knowledge representations which they can later apply to realistic tasks

3. Dialectical Constructivism – Learning occurs through realistic experiences, although learners require scaffolding provided by teachers or experts as well as collaboration with peers.

Interestingly, according to some ( e.g. Dalgarno (2001)), traditional CAI/CAL programs of the drill and practice variety are pre-constructivist, while hypertext, hypermedia, simulations and microworlds are examples of endogenous constructivism. Simulations and microworlds are important computer-based, mathematics learning environments discussed below in section 3.7 on teaching mathematics using CAI.

## 3.7 CAI-based Mathematics Teaching in PNG

### 3.7.1 General Context of CAI-based Mathematics Teaching and Learning in PNG

As stated in chapter 1 the aim of the present study is to investigate the efficacy of a computer-based method of mathematics instruction, particularly the effectiveness of CAI in mathematics instruction in the PNG context. Mathematics is one of the core subjects in school in PNG and is a pre-requisite together with English to entry into tertiary study.

However, while mathematics is the facilitative vehicle for the core investigations of the present study, it was not the central focus of the study per se. Consequently, the theoretical underpinning of the field of mathematics education is ignored in the present thesis. The researcher felt that the field of mathematics education was extraneous to the aims of the present study, which focuses more teaching through a CAI mode. In Chapter 4 – Methodology it is noted that the present study accepts an existing mathematics course at face value and proceeds to conduct the investigations on the efficacy of a computer-based method of instruction.

McCoy (1996) stated that the great change in the mathematics education that occurred in the US in the seven years prior to 1996 came about with technology as an integral part of the reform. He contends that:

> The underlying philosophy is constructivism, which asserts that students learn mathematics by active involvement with mathematical models that allow them to internally construct their own understandings and concepts. This means a decrease in the amount of drill and practice in any medium and increased interaction with a variety of models of mathematical concepts. Computational skill is de-emphasized and use of calculators and computers is encouraged. Computers are extremely important because they can provide a variety of rich experiences that allow students to be actively involved with mathematics (p. 439).

While research has moved on in the developed world in the PNG context, it has hardly begun. Very often when computer-based, learning systems are adopted (and there are very few documented cases of this in PNG to the researcher's knowledge) they are adopted without research-based foresight. This may be slowly changing, as noted recently by the organiser of the University of Goroka (UOG) Faculty of Science Conference (2001), based on the number of papers presented on computer-based learning. The papers were mostly in the area of mathematics.

In view of the relative newness of computer-based educational technologies in mediating learning in PNG, it is necessary that a research such as the present study in the PNG context recognises this relative lack of use. This is an important note in view of more recent efforts to move away from certain forms of CAI such as 'drill and practice'. The present study has aims that are more modest in that a more interactive form of drill and practice is the form of CAI used to conduct the investigations.

Moreover, the basic drill-and-practice structure of the software was extended with the liberal use of hypermedia style navigation buttons with built-in hyperlinks, linking concept to concept in some sequence. Other CAI objects employed in the software were flashcard and page-turning concepts as well as simulation. The CAI software developed and used in the present study is therefore more than just drill-and-practice, as this form of CAI is commonly understood. Most importantly though the software was deployed in an unfinished form due to time limits and therefore did not have the full functionality and all the features that a completed software would otherwise have.

Furthermore, the nature of the investigation and the type of CAI used was somewhat dictated by the nature of the course, mathematics 2. Mathematics 2, as noted in chapter 4, is the mathematics course used as the domain for the present study. The researcher is of the view that current requirements in mathematics 2 may not demand such a high level of thinking from the students. An extended drill-and-practice CAI mode was adopted in the present study in deference to the traditional practices in teaching mathematics 2, and the conceptual depth of coverage of the topics in the course. The researcher's aims were to automate a particular pedagogical style (Balacheff and Kaput (1996)), which CAI is good at facilitating. Section 3.7.2 below discusses further the reasons for adopting CAI instead of the other forms of computer-based mathematics learning systems. The discussion proceeds in the context of computer-based mathematics learning environments.

### 3.7.2 Computer-Based Learning Environments in Mathematics

A crucial question that a mathematics teacher needs to ask when adopting a computer-based learning environment is, what kind of mathematics learning environment is appropriate for the particular group of students? This is because not all computer-based mathematics learning environments affect mathematics learning in exactly the same way. Balacheff and Kaput (1996) noted and discussed the differences in learning effects among mathematical learning environments such as microworlds, AI, CAI and algebraic learning systems e.g. MathLab, as well as statistics and mathematics modelling. They noted that computer-based learning environments, other than CAI systems, compared to other types of learning materials, are intrinsically cognitive in character i.e. they assume a constructivist learning paradigm. They noted that:

> Concrete material such as blocks for the learning of counting and early arithmetic, or mechanical drawing systems, or audio-visual technologies do not embody the key feature of a computer-based environment: it computes formal representations of mathematical objects and relationships. The interaction between a learner and a computer is based on a symbolic interpretation and computation of the learner input, and the feedback of the

> environment is provided in the proper register allowing its reading as a mathematical phenomenon (p. 469).

Mathematics Microworlds e.g. Logo turtle geometry and Cabri-geometre to name just two, provide a dynamic semantics which allow the learner to explore simultaneously the structure of the accessible objects, their relations and the representation that makes them accessible. Microworlds evolve as the learner's knowledge grows (Hoyles, 1993: p. 3).

According to Balacheff and Kaput (1996), microworlds consist of the following interrelated features:

1. A set of primitive objects, elementary operations on these objects, and rules expressing the ways the operations can be performed and associated - which is the usual structure of a formal system in the mathematical sense.
2. A domain of phenomenology that relates objects and actions on the underlying objects to phenomena at the 'surface of the screen'. This domain of phenomenology determines the type of feedback the microworld produces as a consequence of user actions and decisions.

In contrast to microworlds, which involve changing the mathematical experience of learners at the epistemological level, CAI facilitates and automates a particular learning style. The problem in a mathematics microworld in the PNG context is the relationship of the knowledge taught as it results from the behaviour of the system with the knowledge its designer intended it to teach. The order in which actions take place would seem to be arbitrary in the eyes of the users (Balacheff and Kaput (1996)). In other words, it is quite conceivable that the learner may not realize the intended learning outcomes in these relatively freewheeling learning environments. This could well pose problems for mathematics syllabi that make use of summative assessment examinations at the end like that in mathematics 2. This, in fact, was the reason for the decision to adopt a CAI-based mathematics teaching system in the present study instead of the other mathematics learning environments, even if others have the potential to engender a more constructivist learning paradigm.

In the CAI-based teaching and learning system, the teacher can direct the learning towards some convergence in the learning outcomes.

The next section discusses the hardware, namely multimedia CD-ROM, which makes interactive CAI possible through its vast storage capacity.

## 3.8 CAI and Multimedia CD-ROM

According to Druin and Solomon (1996) the development of such technologies as CD-ROM has made what was once considered impossible not only possible, but now readily available. CD-ROM, which stands for Compact Disc Read-Only Memory) is a digital optical medium for storing vast amounts of computer data. According to Castro (1990) the attraction and importance of optical disk technology such as the CD-ROM in the educational context is that it is a wonderful vehicle for multimedia delivery and has an immense capacity for data storage. All that is required is that one has access to a computer with a CD-ROM drive.

Edgar (1992) explained multimedia as:

> The integration of audio, graphics, animation and text, using the computer as a control and presentation platform so as to enhance significantly the learning and information environment. Multimedia integration allows us to interface with computer-based applications using our more natural information acquisition senses of touch, sight and sound, in a way which can provide a flexible insight into subject material with the user being interactively involved in the learning process (preface).

More specifically on the case for multimedia in education Perzylo (1993) had this to say on the potential for Multimedia CD-ROM:

> Multimedia CD-ROMs have the capacity directly to influence the style of education and the types of skills emphasized in schools and the work place far more than any other technological innovation (p. 192).

Other than the CD-ROM, there are now other devices, which perform the same function as the CD-ROM since the observations noted above. More recently, multimedia software developers have used devices such as Zip Drives, which utilise special 100-megabyte or greater capacity disks. Very closely related to the CD-ROM is the DVD, which has a capacity even greater than that of the ordinary CD-ROM although the CD-ROM is still more versatile compared to the DVD. It is now possible for anyone with a CD-ROM drive with read/write/rewrite capacity to record multimedia software or any other computer file on a CD-ROM, whereas DVD still requires specialist hardware and software for writing on the media.

Given the relatively small size of the half-completed, prototype CAI developed for the present study it was not necessary to employ CD-ROMs in the production of the software. Instead, 100-megabyte capacity zip disks using zip drives were employed as storage media in the production of the software with the intention eventually of recording the 'finished' product on CD-ROMs.

In the next section studies on CAI use are reviewed. These studies demonstrate the effectiveness of CAI in the process of teaching and learning, particularly in the area of mathematics.

## 3.9 Review of Some Studies of CAI Use

### 3.9.1 Introduction

The literature reviewed in this section looks at the CAI aspect of CMC and how it has been used around the world to mediate teaching and learning.

The researcher aims to address the following main questions in the literature review. Does the use of CAI in mediating educational instruction result in a significant improvement in student understanding and achievement, especially in mathematics? What does the research literature show about the effectiveness of CAI in mediating teaching and learning in mathematics?

The review examines practices in two areas of CMC: computer–assisted instruction (CAI), and online (internet-based and web-based) teaching and learning. The focus on web-based learning is very limited with the greater focus being on CAI.

Due to the constraints imposed on PNG students by the lack of ready access to computers, the literature review and study focuses on areas of CAI as facilitated by CD-ROMs and other similar multimedia-enabling hardware. The present study adopted CAI because the researcher felt that CAI does not rely too heavily on facilities that either do not exist or are still very much in their initial stages in PNG.

While the Internet and the WWW are becoming more prevalent in PNG to those with computer access, these facilities are not yet widely available in the country to make them viable teaching media at present. This observation notwithstanding, the day when they become viable is not far off given the current rate of implementation of these information acquisition tools in all sectors of PNG society, including education.

### 3.9.2 Some Brief Background

Going back to the defining ideas of CAI by Santoro (1995), noted earlier in section 3.4, *Computer-assisted instruction (CAI)* is where the computer structures and manages both presentation of information and the possible choices available to the human user. The main idea behind CAI is the systematization of the instructions to the human user into an algorithmic process. A computer program written by the developer who may be the teacher then enables the computer to interactively deliver the instruction.

According to Santoro the main advantages of CAI courseware are:

1. the student is able to learn at his or her own pace
2. a reduced dependence on a human instructor

These two advantages alone immediately make CAI attractive to education in general and most certainly to distance education in Papua New Guinea. It has long been recognized that there are many slow learners in any given course who get left behind, thoroughly confused, in the rush by the instructor to completely cover the course in the given time. Alternatively, the tutor can choose to cover the materials at the rate of the slowest learner. Either situation is highly unsatisfactory. These situations are certainly prevalent in the matriculation courses, which include mathematics 2, in the Institute of Distance and Continuing Education (IDCE) at UPNG.

In the distance education situation, many students in the remote areas of Papua New Guinea are entirely dependent on the written materials, which are limited in their effectiveness as discussed earlier. An interactive course on CD-ROM could well supplement written materials resulting in improved learning outcomes.

Fitzgerald and Koury (1996: p. 527) observed that CAI is used to refer to the use of computers and other associated technologies as a form of instruction. They proposed that the focus of CAI studies since such studies began fall into two broad categories as follows:

1. A simplistic comparison of computer-based versus traditional instruction.
2. The investigation of the instructional conditions that may impact student outcomes utilizing CAI such as attitude.

The literature review in the next section (section 3.9.3) first examines meta-analyses of studies on the effectiveness of CAI and then looks at specific studies considered relevant to the aims of the present study in different contexts. In particular the focus is on studies on CAI effectiveness in mathematics.

### 3.9.3 Studies Showing CAI Effectiveness in General

#### Meta-analyses

A large number of meta-anlyses have been conducted since about the mid-sixties on computer-based instruction, particularly in the form of computer-assisted instruction. The method of meta-analysis, to locate studies, describe study features and outcomes and summarize overall findings, as first used by Glass (1976), takes a more quantitative approach to literature review on a subject. It attempts to draw out an overall conclusion from the conclusions of various specific studies. According to Kulik, Bangert and Williams (1983), meta-analysts use:

1. objective procedures to locate studies
2. quantitative or quasi-quantitative techniques to describe study features
3. Statistical methods to summarize overall findings and to explore relationships between study features and outcomes.

The following are some of these meta-analyses on the effects of CAI application on teaching and learning as compared to traditional instruction.

Khalili and Shashaani (1994) conducted a meta-analysis of 36 independent studies, which showed that computer applications have a positive effect on students' academic, achievement from elementary school to college.

Some significant findings of the meta-analysis by Khalili and Shashaani were:

1. There was no observable improvement in student performance as a result of the effect of computer technology over time in the five years looked at in the study.
2. Improvements in computer technology did not necessarily translate to better student performance.
3. Duration of instruction was found to be significant i.e. the longer the length of treatment the more significantly better was the positive effect.
4. Different computer applications showed different levels of effectiveness.
5. The effect of computer use on learning was greatest on mathematics achievement.
6. The best results on effectiveness of computer in learning were noted for students at the high school level.

This meta-analysis was very much based on studies which were themselves reviews in the mold of meta-analyses by Vinsonhaler and Bass (1972) and by Edwards, Norton, Taylor, Weiss and Van Dusseldrop (1975). These were studies published between 1966 and 1973 on computer-assisted instruction (CAI).

Vinsonhaler and Bass had focussed on studies of CAI that provided drill and practice in mathematics, language, and the arts in elementary schools. They noted a significantly better, positive association between computer-augmented instructions and students' achievement than that with traditional instruction (TI).

Edwards et al. (1975) had also noted a similar positive association between CAI and student performance but on a less consistent basis than in the studies examined by Vinsonhaler and Bass. Edwards et al. found that CAI often produced better results than traditional modes of instruction on end-of-course examinations but not on retention examinations.

Given that one of the specific aims of this study is to investigate the effectiveness of CMC in the form of CAI in the teaching and learning of mathematics at the adult matriculation (high school) level, the effectiveness patterns observed in this meta-analysis certainly support the aims of the present study. The results suggest that CAI is an effective method of teaching mathematics to students and that student learning through CAI is effective.

A criticism of this meta-analysis is that it depends too much on old CAI studies before 1980. Most of the studies on which the meta-analysis was based preceded the introduction of the PC. The arrival of the PC in the early eighties heralded the evolution of bona fide interactive computer multimedia hardware and software such as the CD-ROM for instance. (Sony and Philips first introduced the CD-ROM in 1982 as a music storage device.)

As noted by Fitzgerald & Koury (1996), one of the main criticisms of studies of CAI versus traditional instruction (TI) in this period of CAI development was the simplistic comparison of computer-based versus traditional instruction. Detailed examinations of some of these criticisms (e.g. Clark (1984)) are considered in section 3.14 further on in this chapter.

Christmann, Badgett and Lucking (1997) also conducted a meta-analysis comparing academic achievement of students in grades six through twelve in eight subject areas, including mathematics, in which students were either given traditional instruction (TI) only or TI supplemented with CAI. Again, as in the meta-analysis by Khalili and Shashaani, Christmann et al. found that the students who had TI supplemented by CAI attained higher academic achievements than did those who received only TI. In contrast to Khalili and Shashaani though, Christmann et al. found that the greatest positive effect of CAI was in the subject area of science as opposed to mathematics.

It is also important to note that Christmann et al. studied the effect of TI supplemented by CAI rather than TI replaced by CAI as seems to be the case in the studies summarized by Khalili and Shashaani. This is more in line with the direction that the present study takes in that the intention is to supplement traditional instruction with CAI rather than replace it with CAI.

An earlier study which used quantitative techniques or meta-analysis and which looked specifically on the effects of computer-based teaching on secondary school children was that by Kulik, Bangert and Williams (1983). In this review, 51 independent evaluations of computer-based teaching in grades 6 through 12 were considered. Again, consistent with other reviews, the analysis showed a marked improvement in student achievement on final examination scores. The students also developed very positive attitudes towards the computer and the course taken.

An additional important finding was that the positive effect on a follow-up examination, while much lower than the final examination immediately after the course, continued. This is no different to what happens in situations where traditional modes are used for instruction. A certain amount of loss does occur over time following the instruction.

The 3 meta-analyses noted thus far would have considered all studies including those that did not support the effectiveness of CAI in improving student achievement as well. The net effect of the analyses of these studies seems to support the view that CAI application in student instruction results in a significantly positive improvement in student achievement.

Jamison, Suppes and Wells (1974), in a comprehensive survey of alternative instructional media, concluded that CAI is effective as a supplement to regular instruction at the elementary school level.

Hartley (cited in Kulik, Bangert and Williams (1983: p.526)) further attest to the conclusions reached in studies looked at thus far. The overall conclusion from the synthesis of the results showed that CAI was a very effective method of teaching mathematics at the elementary and secondary levels.

Burns and Bozeman (1981) also used the method of meta-analysis to integrate findings on computer-assisted mathematics instruction in elementary and secondary schools. They also found a positive association between CAI and achievement in mathematics.

### 3.9.4 Studies Showing CAI Effectiveness in Developing Countries

Most of the studies cited in this literature review on the effectiveness of CAI use in education have been conducted in settings in the developed world such as the USA, Canada and so on. While there are very few studies on the effectiveness of CAI use in education in the developing world, there are nonetheless a few examples.

Barry and Phalavonk (1992) reported patterns in effectiveness of CAI in learning mathematics amongst university level, Thai students similar to the patterns noted in the previously cited studies. They also noted that the use of CAI in teaching mathematics resulted in higher achievements than that by traditional teaching methods only.

Besides noticing that CAI-taught students did better than the other students, they also observed an unexpected result in their study. Students exposed to CAI in previous topics did better than students with no exposure to any CAI instruction even when the instruction to both groups was by traditional modes.

This finding would seem to suggest that exposure to CAI helps to foster better organization of ideas in mathematics amongst participants, so that even when CAI is not being used, the effect of the exposure continues to bear positive results in subsequent work in mathematics.

A study by Scott (1988) in Guatemala in a rural Indian community setting also showed positive results in mathematics achievement when students were exposed to computer-based learning in mathematics. Although the Indian students in this case were exposed to a Logo mathematics environment and not CAI per se, the study showed that even with limited resources, computer-based learning modes are effective. (There were only two apple computers available to the students). A significant observation in the study was the fact that the Logo commands were in English, the error messages were in Spanish and the students discussed their work in a local Indian language called Quiche.

Studies in this area and to this effect are virtually non-existent in Papua New Guinea at all levels of the education system. An exhaustive search of literature on research in teaching mathematics using CAI to Papua New Guinean students found only two examples of attempts to study the effect of the application of CAI on students' performance in mathematics. Krajcsik (1994) carried out a study on the effect of using TEMATH (Tools for Exploring Mathematics) on student performances in mathematics achievement of first year teacher trainees (post grade 12) at Goroka Teachers College (now the University of Goroka). He used a pretest/posttest format to test the effectiveness of the instruction. Although the original idea was meritorious and along the right general direction no conclusive findings are reported. This may well have been due to the reported cited here being a progress rather than a final report of research. Certainly if a final report was made of this study the present researcher has not sighted it.

A study by Boeha and Aung (1997) conducted at the Papua New Guinea University of Technology (Unitech) in 1992 in which CAI was introduced to different groups of students was reported at a UNESCO conference in Melbourne.

This study had severe weaknesses in methodology. Firstly, the responses to a one-item questionnaire given to visitors from high schools to an Open Day at the University of Technology was used to make conclusions about some nebulous qualities labelled "interest" and "effectiveness" in rating CAI. A 6-item questionnaire on effectiveness and interest, which the researchers designed following this, was applied to 24 students in a particular course.

Secondly, the so-called control and experimental groups were different and there is no evidence of any attempts to justify statistically associating the two groups as control and experimental groups.

Thirdly, the pretest and posttest both consisted of one item each.

Fourthly and finally, the sample sizes were rather small: 10 students in CAI and 9 students in the control group.

The important point in noting these research attempts though is the fact that attempts have been made as exemplified by these two examples, however small and inconclusive they may have been, to study educational outcomes as a result of applying some form of CAI in a Papua New Guinea context. The bulk of the literature though has been of a descriptive nature rather than that of research.

The writer does acknowledge that four years in computer technology development terms is a long time, because of the speed at which computer technology has developed and is developing in PNG. The researcher has been absent from PNG for four years and as noted earlier, recent educational conferences in PNG in the area of mathematics and science in particular have had papers on computer assisted teaching and learning research.

Since the two studies noted above there have been many developments in the area of computer technology use in Papua New Guinea, especially in the education sector. UPNG for instance connected to the Internet in late 1997. The Mathematics Department at UPNG has recently utilised computers and computer-based methods to teach some aspects of mathematics in a number of mathematics courses.

Computer-based lessons have also been utilised in courses in other disciplines at UPNG as indicated by the heavy bookings of the few computer laboratories available. Computer-based mathematics courses have also been on offer at the Department of Mathematics and Computer Science of the Papua New Guinea University of Technology (Unitech).

### 3.9.5 Extended Description of Individual Studies on the Effectiveness of CAI

A quick search through the literature on CAI-based mathematics instruction brings up a sizable number of specific research studies into the effectiveness of CAI in improving student achievement in mathematics as well as in other subject areas.

Only two of these studies are considered in any detail here due to space limitations. The consideration of a number of meta-analyses has already given a broader picture. A small sample of the rest of the studies considered relevant to this research is listed in tabular format, together with the main findings of the particular study.

A study involving exposing students to CAI instituted in a border community in Texas amongst mostly poor Hispanic students, considered having limited English proficiency (LEP) is of some interest to this study. The situations of high poverty rates, limited English proficiency and over-crowded school conditions are arguably not much different to that which exists in Papua New Guinea. In the Texas study instituted between 1987 and 1988, 119 students from grade one to grade 12 in San Elizario, Texas, were provided CAI in mathematics, language arts, and computer literacy, as well as science and social science to older participants. Comparisons of

1987 and 1988 standardized test scores showed improvement for most grades. The greatest improvement in achievement in mathematics occurred at the grade 6 level. The study also found some other interesting trends such as lower absenteeism and dropout rates amongst the project participants.

Another study on the use of CAI in school in a situation which can be considered equivalent to some degree to that in Papua New Guinea was conducted in Grenada, although in this case a CAI that was developed in the United States for US children was used without any adaptation to children in Grenada. The results from this study were mixed. In reading, no positive association with CAI use and achievement was found, whereas in mathematics there was some positive ass[illegible] in achievement with CAI use varying somewhat inconsistently from [illegible] grade. This study was conducted at the elementary school level. The authors state that this study was conducted mainly to see what pointers could be gleaned from the results to better design a future study especially if the results showed some positive association between CAI and student achievement.

The rest of the studies showing effectiveness of CAI in mediating teaching and learning, which are relevant to the present study, are listed below in table 3.1 in studies 1-9.

The table below is a summary of a sample of 9 studies considered relevant to the aims of the present study on the effect of CAI on achievement, as compared to traditional instruction. The table summary leads into a summary of the general trends noticeable in the results of studies in CAI in general.

***Table 3.1: Summary of Studies of CAI Effectiveness in Teaching and Learning***

**Study # 1**

| Author/Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| [Williams, G. R.,<br>(1993)<br><br>USA | Efficacy of CAI in the areas of math application and reading comprehension | 6th Grade<br>- maths<br>- reading | • 54 randomly selected subjects<br>• 2 x 20 min sessions of CAI per week<br>• 10 mins math/10 min Reading | • significant improvement in reading comprehension<br>▪ no difference in area of math application |

Study # 2

| Author/Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Roberts, V.,<br>Madhere, S.<br>(1990)<br><br>USA | Resource Laboratory Program for CAI 1989-1990. Evaluation Report. | Elementary<br>Junior High<br>-maths<br>-reading | • evaluation of Resource Lab. Program for CAI<br>• students assisted by a teacher & an aide | • No significant gains in reading achievement<br>▪ Significant gains in math achievement |

Study # 3

| Author/Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Ford, B. A.<br>Klicka, M. A.<br>(1994)<br><br>USA | The effectiveness of CAI supplemental to classroom instruction on achievement growth in courses of basic and intermediate algebra | Community College<br><br>-maths | • 4 Classes (n=53) of basic algebra<br>• 5 Classes (n=50) of intermediate algebra<br>• Supplemental to Classroom instruction | • Based on standardized pre- and posttest scores students using supplemental CAI in basic algebra had significantly higher achievement growth than students not using supplemental CAI<br>• In intermediate algebra there was no significant difference in achievement growth |

**Study # 4**

| Author/Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Reglin, G.<br>(1987)<br><br>USA | Effects of CAI on mathematics and locus of control | High School pre-entry to teacher training<br><br>-maths | • Minority students do poorly on South Carolina's Educ. Entrance Exam (EEE) in the maths section of the paper.<br>• This study investigated the effects of CAI on basic skill maths achievement amongst black students.<br>• Pretest/posttest format<br>• Experimental group received 30 minutes of CAI each session | • CAI increased students' mathematics scores<br>• Developed a more internal orientation through the use of CAI. |

**Study # 5**

| Author<br>Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Becker, H.<br>(1990)<br><br>USA | Effects of computer use on Mathematics achievement. Findings from a nation wide field experiment in grades five to eight. Classes: Rationale, Study Design, and aggregate effect sizes. Report No.51 | Grades 5, 6, 7 & 8 | • 48 classes of computer instruction and 48 classes of traditional instruction taught by 56 teachers in 31 schools from 25 districts in 16 states participated in this experiment in the first year. In the second year 11 teachers from 9 schools employed same teacher-control design<br>• Various computer hardware and software used<br>• Most classes used computers for drill and practice problems. Several used problem-solving tasks built into the programs<br>• Pre- and Posttest format in analysis of effect of instruction | • No significant results in effect sizes |

**Study # 6**

| Author/Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Walker, E.<br>Azumi, J. F.<br>(1985)<br><br>USA | The impact of CAI on mathematics learning gains of elementary and secondary students | Elementary & High School -maths | This research was based on the following questions<br>• What is the relationship between attributes such as sex, ethnicity, socio-economic status, ability and maths achievement in computer-based educational programs<br>• Are there demonstrable differences in maths gain that are related to various content standards?<br>• How do such instructional factors as time on task and instructional management impact on achievement?<br>• Drill and Practice CAI | • At the primary level (grades 2&3) students of higher ability made greater gains on the computer program<br>• No significant differences in performance at the intermediate level (grades 4, 5, 6)<br>• At grades 7 & 8 level students of lower ability had greater gains<br>• Findings at the secondary level suggest that CAI maximized individualized instruction and had beneficial learning effects for all ability level students. |

**Study # 7**

| Author<br>Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Moore, A. (1993b)<br><br>Canada | Computer-assisted instruction for adults | Adults in a community in Canada | • INVEST computer assisted learning system established with basic instructional software offering lessons in reading, writing, mathematics and life skills.<br>Questions investigated.<br>• Could an heterogeneous group of adult learners make significant gains in academic achievement over an 11-week period ?<br>• How do such gains compare to more traditional learning approaches? | Results of standardized skills tests and evaluation questionnaires indicated the following:<br>• Positive gains were made in all areas of reading and math with gains of more than 1.5 years realized for mathematical concepts and problem-solving<br>• 73 % of participants felt project should have been longer.<br>• 80 % of Participants indicated more highly motivated<br>• 73% of participants felt that they were better and more confident learners.<br>• 80% of participants indicated they wanted more instructor input<br>• Overall consensus was that there were many positive features to the program which could serve as a successful adjunct to traditional models. |

**Study # 8**

| Author<br>Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Swarm C. (1991)<br><br>USA | Computer-assisted mathematics prescription learning pull-out program in an elementary school | Elementary school ( 5th and 6th grade) | • Non-experimental study<br>• Conducted on students who were 1 to 2.5 years behind in mathematics achievement scores<br>• Students from wide variety of ethnic groups<br>• 80% of students spoke English as a second language<br>• Students visited computer lab once per week for a 40 minute session<br>• Students received individually prescribed learning packet of computer-assisted program | • Results from end-of-the-year mathematics achievement tests indicated significant gains in their scores<br>• Noted a positive relationship between the performance of students on the achievement test and their mathematical conceptual performance |

**Study # 9**

| Author<br>Location | Title | Level<br>Subject area | Brief Description | Results |
|---|---|---|---|---|
| Schalago-Schirm Cynthia (1995)<br><br>USA | Does the computer-assisted remedial mathematics program at Kearney High School lead to improved scores on the N. J. Early Warning Test? | Grade 9<br><br>- Mathematics | • Students in N. J. take Early Warning Test (EWT) in Grade 8. Students with Early Warning Test (EWT) scores below state level of competency required to take a remedial mathematics course<br>• Students doing this remedial math course are provided with CAI 2 days per week besides regular classroom instruction<br>• Study involved 73 ninth grade students at Kearney High School on the remedial course.<br>• CAI provided to help students attain proficiency in the math section of a state-mandated high school proficiency exam<br>• Students retested with N. J. Special Edition EWT – Grade 9 after 6 months on CAI<br>• Sample mean scores from 2 years (1992 & 1993) compared | • Results indicated a statistically significant gain<br><br>• More than 50% of the sample still needed further remediation |

### 3.9.6 General observable Trends in studies on CAI effectiveness

The list below summarises some of the trends on achievement gains in mathematics and other subjects, due to the application of CAI in the studies cited.

1. CAI results in overall achievement gains in mathematics at every level from elementary to college level
2. CAI is most effective at elementary school level, slightly less effective at high school level and least effective at the college level
3. Students of lower ability seem to gain most from CAI which accounts for the observation that students undergoing remedial work seem to benefit most from CAI
4. CAI seems to be most effective with lower-level thinking skills such as drill and practice than with higher-order thinking skills in mathematics

5. Students' attitudes towards computers seem to improve with CAI exposure.
6. CAI is more effective as a supplement to regular classroom instruction, than as a replacement for regular classroom instruction.
7. CAI reduces instructional time in learning math concepts.

Jamison, Suppes and Wells (1974) and Niemec and Walberg (1987) are among some of the researchers that have noted that CAI seems to be most successful at the lower grades (elementary) than at the secondary and college levels.

The trends noted above give quite a lot of support for the use of CAI in providing instruction in mathematics, although this is somewhat tempered by criticisms that some studies in this area were simplistic (Fitzgerald, 1996) and that questions on whether CAI is effective compared to traditional instruction may even be wrong (Bracey, 1987).

Bracey, while expressing some doubt on studies regarding the comparison of CAI versus traditional instruction, nevertheless affirmed the trends as noted and listed above when he stated that;

> There wasn't a lot of research on CAI, but what existed was mostly positive, suggesting that children learned more, retained more, or learned as much in less time. Some evidence hinted that computers were especially good for slow learners or "special populations "(p. 22).

Bracey tempers this more glowing endorsement of the positive effects of CAI somewhat when he goes on to say that "as encouraging as they might have been then, today these studies are practically obsolete". He states as a reason for this situation the fact that many of the earlier studies were conducted in controlled laboratory settings using mainframes and mini computers. This situation is vastly different from much computer-based education or instruction in the nineties which is multimedia based and run on PCs, whether standalone or networked.

Since the studies noted in this section (3.9) research has moved on. Recently there has been a call for a change in direction (Reed, Spuck and Bozeman (1996)) in the way the research questions in Computer-based instruction have been framed.

## 3.10 Change in Direction of Research in Computer-based Instruction

Reed, Spuck and Bozeman (1996) in their introduction to the special issue of the Journal of Research on Computing in Education, noted that the direction of research in CAI has somewhat changed since around 1988. Where as in a typical study design on computer use the researcher used to divide a class of students into an experimental and control group (Kulik, Bangert and Williams (1983)) this is not often the case anymore. Since around 1988, due mainly to the rise of action research or classroom-based research,

> the designs have had all samples and sub-samples within a given study engage in the computer-based treatment, and differences based on student characteristics, such as ability, age, attitudes, or learning style are determined. Not very often anymore is a noncomputer group pitted against a computer group. This design decision is based, in part, on earlier research that consistently found that computer groups performed "better" (Reed, Spuck and Bozeman (1996: p.415)).

Reed et al. go on to claim that the change in direction of research has "also addressed the issue of authentic instruction and research settings, which has better reflected the notion of constructivism and length of treatment". This change in direction has also addressed criticisms of research in computer-based instruction by such noted critics of computer-based learning as Clark (1983) for instance.

## 3.11 Criticisms of Studies Comparing Traditional Instruction (TI) to CAI

Based on his analysis of computer-assisted instruction research and meta-analyses that were current then, Clark (1983) proposed that research in CAI may not have addressed quite the right questions. His criticisms were basically that the research studies, as they were being conducted, were comparing the presence versus the absence of media which he held was tantamount to attributing the nutritional effects of groceries to the truck that delivered the groceries. He contended that:

> The most common sources of confounding in media research seem to be the uncontrolled effects of (a) instructional method or content differences between treatments that are compared, and (b) a novelty effect for newer media, which tends to disappear over time (p. 448).

Some of the questions that needed closer examination, according to Clark, were:

1. Does the newer medium yield more learning than the older or more conventional medium for instruction?
2. Is there an interaction between instructional medium and curriculum content (i.e. do some media teach certain content more effectively than other methods)?
3. Is there an interaction between instructional medium and instructional methods (i.e. do some media present certain methods better than other methods?
4. Are there specific features of newer media that have unique cognitive or behavioral effects for learners?

One of the major points of contention leveled against CAI by its critics is that while it seems to be effective for the acquisition of facts and computation, as in drill and practice in mathematics, there remained questions on its effectiveness in teaching higher-order, mathematical-problem-solving skills (Fitzgerald and Koury (1996: p536)). Fitzgerald and Koury were looking at students with learning disabilities when they made this observation. Khalili and Sashaani (1994) for instance highlight this contention when in their meta-analyses they include as a major component of the meta-analysis, studies reviewed by Vinsonhaler and Bass (1972) which were basically all on drill and practice.

A recent debate in an e-mail discussion concerned with CAI (DEOS-L listserv) highlighted yet another point of contention on the efficacy of CAI instruction. Although this debate was on TI versus Virtual Instruction (VI) and not on TI versus CAI per se, the criticisms leveled are relevant to CAI. Many list members rounded on a study by Schutte (1996) in which he divided 33 students into two groups and proceeded to teach one group in the traditional classroom mode and the other virtually on the World Wide Web. He concluded from his study that there was a 20 % improvement in performance of the virtual group over the traditionally taught group. Most DEOS-L listserv members commenting on the study criticized the result as being highly affected by what they termed as the "Hawthorne Effect".

Basically the Hawthorne Effect as applied to educational experimental situations holds that students who are aware that they are being studied have a tendency to perform better than those who are not aware they are being studied. It would not matter whether the learning conditions the students are subjected to are good or bad, as long as attention is focussed on the students and they are aware of it, they will perform well. The Hawthorne Effect is not to be confused with Clark's novelty effect, which is yet another confounding effect for researchers investigating the efficacy of CAI.

Neal (1998) specifically set out to critically analyze this study by Schutte. Neal attacked Schutte's research design and methodology as severely flawed. According to Neal "students in the virtual class experienced a completely different method of teaching from those in the traditional class"(p.1). The main thrust of Neal's criticism seems to be that Schutte did not control all the variables that were brought to bear on his experiment effectively therefore the conclusions were defective.

It seems that the debate on the comparative effects of TI as opposed to CAI has unnecessarily divided interested researchers into two camps; champions of TI and champions of CAI when the debate really does not call for either.

At the other end of the debate from that which Schutte's conclusions seem to support is the view that it does not matter what delivery system is used, there is no difference in how students perform. For instance Thomas (1997) highlighted this view with his annotated bibliography on comparative research on technology for distance education, titled the "No Significant Difference Phenomenon", where he lists more than 200 papers supporting the argument of "No Significant Difference".

Neal (1998) who was a severe critic of Schutte (1996) also criticized the argument held by Thomas and others of his persuasion, that the delivery system is totally irrelevant and makes no difference to how students perform. He stated that:

> the studies contained in Russell's list suffer from many shortcomings: the research designs are poorly conceived, the statistical analysis is weak or absent and/or the sample size is too small. Many of the studies do not try to measure learning outcomes at all, but focus instead on attitudinal outcomes- how the student felt about the experience rather than what they learned. The studies that do try to assess student learning as an outcome variable often use tests that measure simple recall of information rather than mastery of higher-order learning (p. 3).

There is therefore a lively debate in the literature on the efficacy of computer-based teaching and learning methods going on. The present study is another effort in addressing the underlying issues of the efficacy of computer-based methods of teaching and learning.

## 3.12 Summary of Chapter

This chapter provides the background to the investigation in the present study by presenting the technological perspective for the study. The discussion looked at some issues, especially in distance education in PNG, which could benefit immensely from an implementation of computer-based teaching and learning methods.

Some factors that are idiosyncratic to PNG, that call for a computer-mediated form of distance education, are geography and the cultural orientations of Papua New Guineans. Another factor, which has assumed greater prominence more recently, is the shortage of tertiary places for PNG students coming out of the expanded primary and secondary school system. The solution to this shortage of tertiary places is now increasingly seen to lie in the direction of computer-based teaching and learning at a distance.

The educational technologies that the present study utilises, in conducting the investigations is a class of computer-base communications technologies known collectively as computer-mediated communications (CMC). In particular, a sub-class of CMC known as computer-assisted instructions (CAI) is investigated in the present study.

The chapter also includes a literature review addressing questions on the effectiveness of CAI use. The dominant theme in many studies on CAI use in the early days of CAI development, was a simplistic comparison of CAI versus traditional methods of teaching and learning. A more enlightened view may be one of efficiency and effectiveness in teaching and learning through all means available including computer-based methods like CAI. The teacher-less classroom is probably a myth as much as the paper-less office was a myth. Nonetheless, computer-based teaching and learning modes can improve distance education practices, especially in PNG where distance education practices have been rooted in text and behaviourist notions of learning.

The researcher points out here that the review of literature on CAI use is not specific to distance education use although the intention was to use the information to implement CAI in a distance education context.

Chapter 4, the next chapter, presents the methodology of the investigation and the pilot study.

# Chapter 4: Methodology and Pilot Study

## 4.1 Introduction

This chapter provides a descriptive account of the general methodology used in the pilot study and later in the main study, the development of the research instruments and the piloting of the instruments.

The account includes:

- A description of the general methodology used in the pilot study.
- A description of the five instruments used in the pilot study and how they were developed.
- A detailed description of the computer software version used in facilitating the study and how it was developed.
- A description of the sampling methodology employed in the selection of the subjects used in the study, the sample population and the demographic characteristics of the sample population.
- The piloting of the instruments and the computer software.
- The analysis of the results obtained from the application of the instruments.
- A discussion of reliability and validity concerns for the scales in the instruments.
- A discussion of the modifications to the methodology and the research instruments stemming from the pilot study
- The results of the few statistical tests of hypotheses generated in the pilot study.

## 4.2 The Research Context in Brief

The introduction of computers and computer-based instructional technologies such as the Internet or www, Computer-assisted Instruction (CAI) and other forms of computer-based media have opened up new vistas for distance education. It is now increasingly possible for teaching and learning to occur in real time and at a near FTF (face-to-face) level at a distance without the tyranny imposed on traditional models of distance education by time and space.

Like many institutions in other countries, UPNG has recently taken its first tentative steps towards adopting a computer-based learning paradigm in its programs through the recent commissioning of an internal fibre optic network and the www on its Main Campus. There is potential for the provision of distance education services at UPNG to become available like never before on the back of these new computer-based learning technologies.

To avoid the pitfalls of the haphazard introduction of new learning technologies though, research is vital to investigate the impact of computer-based instructional models on student learning in the Papua New Guinea (PNG) context. This would ensure that the impact on students' learning is significant for the time, effort and cost expended in introducing them as alternative teaching and learning models. Research would also determine whether this impact is positive or negative. It is well to be reminded again of the statement by Bates (1990: p. 39).

> The history of education, particularly in developing countries, is littered with the corpses of technology-based projects that were killed off because of the high operating costs, problems of adaptation to local conditions, lack of skilled personnel to operate the technologies, and lack of effectiveness.

This study is an outcome of the need to understand how computer-based learning systems impacts on students' learning. In this study the impact of a computer-based instructional model in a distance education course at UPNG is investigated. The methodology, resources and instruments employed to accomplish the aims of the present study is discussed in the following sections.

## 4.3 Research Domain, Computer Software and Instruments used in the Study

The following sections provide the descriptions of the research domain, the computer software developed and used in the study and the development of the research instruments used to collect the data in the study.

### 4.3.1 Research Domain

The domain selected for the present study was the adult matriculation (AM) course, mathematics 2 (27.023), a pre-University level mathematics course offered by the Institute of Distance and Continuing Education (IDCE) at UPNG.

The following is a description of this course and why it was chosen for the present study.

**Mathematics 2 (27.023)**

Mathematics 2 (27.023) is one of the two mathematics courses in the Adult Matriculation (AM) Program offered through IDCE. The researcher therefore did not have much of a choice as to which course to use as the domain for the research, given that there were only two mathematics courses available through the distance mode. Mathematics 2 was chosen ahead of mathematics 1 because it is the better organised of the two mathematics courses.

The AM program is a pre-university level program that runs parallel to the PNG Higher School Certificate (HSC) which is the grade 11 and 12 program. It consists of 8 courses with Mathematics 1 (27.022) and Mathematics II (27.023) being 2 of the four core courses of the AM program. Students are required to sit entry tests in English and Mathematics before they are allowed to enrol in the AM program. Their scores on the entry tests are then used to advise the students on whether they can enrol for any course in the AM program or otherwise. Satisfactory completion of the AM program qualifies a student for University entrance status.

The minimum school grade level that is required for entry into the AM program is grade 10. Hence, to enrol in the mathematics 2 course the student is expected to possess a good grasp of at least a Grade 10 level of mathematics or equivalent, as well as completion of mathematics 1 (27.022). Students who do poorly in grade 12 (HSC) can also use the AM program as an alternative route to achieving University entrance status. The mathematics 1 and mathematics 2 courses together are roughly equivalent to the grade 11 and 12 mathematics syllabus in PNG schools. Although there is an impression among those concerned with University Entrance requirements in PNG that the two courses are of a somewhat lower standard than that required in the HSC. However this impression is not based on any researched evidence.

The course is completed as it is set out in the nine course booklets that comprise the course. The nine course booklets represent the nine topics in the course and the students are required to have access to these booklets when they enrol for the course. Table 4.1 below provides a list of the nine topics in the mathematics 2 course.

*Table 4.1: List of Topics in Mathematics 2 (27.023)*

| **Topics** | **Description** |
|---|---|
| 1 & 2 | Straight Lines and Systems of Linear Equations |
| 3 | Evaluation |
| 4 | Products and Factors |
| 5 | Quadratic Equations and Parabolas |
| 6 | Indices and Surds |
| 7 | Further Quadratic Equations |
| 8 | Trigonometry |
| 9 | Linear Inequalities |

### 4.3.2 Computer Software used in the Study

The computer software used in the pilot study to provide instructions in the mathematics 2 course content to the students in the CAI group was **Lebo 1.0 – An Interactive Mathematics 2 Project**. This software was developed specifically for the present study by the researcher. The following sections describe how the decision to develop this software was arrived at, and how it was developed and validated for use in the study.

#### 4.3.2.1 Designing a CAI Software

The researcher had hoped that there were existing, off-the-shelf computer software packages to deliver the computer-based instructions in mathematics 2. But an exhaustive search produced nothing sufficiently suitable or affordable for the purpose; hence the decision was made to develop a home grown program specifically for this purpose. The reason for this decision was mainly because the content of the instruction had to follow the syllabus of the mathematics 2 course as set out in the course booklets very closely. There was no desire on the part of the researcher to re-invent the wheel (software) as it were, if it was already in existence.

The researcher was mindful of the fact that students who were involved in the research were not members of a purely experimental group set up solely for the purposes of this study. They were in fact real students enrolled in the actual mathematics 2 course for semester 2, 1999. With this in mind, all necessary efforts were made to ensure that any teaching method the students were subjected to would not be detrimental to their learning even if it did not fulfil research expectations. While there were pre-existing mathematics software packages that dealt with some of the topics that were in the mathematics 2 course in various combinations on the market, it was felt that they were somewhat inadequate to meet the instructional needs of the research sample. This was because software that did not follow closely the topics and topic sequencing of mathematics 2, as they appeared in the course booklets (see table 4.1), was considered inadequate.

The researcher feared from past experience teaching mathematics 2 students that any unfamiliar deviations from the syllabus of the course as presented in the written materials would have lead to much confusion, thereby rendering the CAI mode ineffective before it even started.

There was also the need to minimise the variables under observation by keeping all other aspects of instruction between the experimental group and control group as constant as possible. This meant that issues such as length of instructional time, frequency and number of tutorials and extra tutorial help had to be kept as uniform as possible over the two groups. Both groups were also allowed access to the 9 course booklets in further attempts to keep all other variables constant. In the experimental design the only variable that was going to be observed was the mode of instruction.

In accordance therefore with the foregoing considerations the researcher developed the **Lebo 1.0 - An Interactive Mathematics 2 Project**. It was a standalone computer program written specifically for use in this study to mediate instruction in mathematics 2.

#### 4.3.2.2 Lebo1.0 - An Interactive Mathematics 2 Project

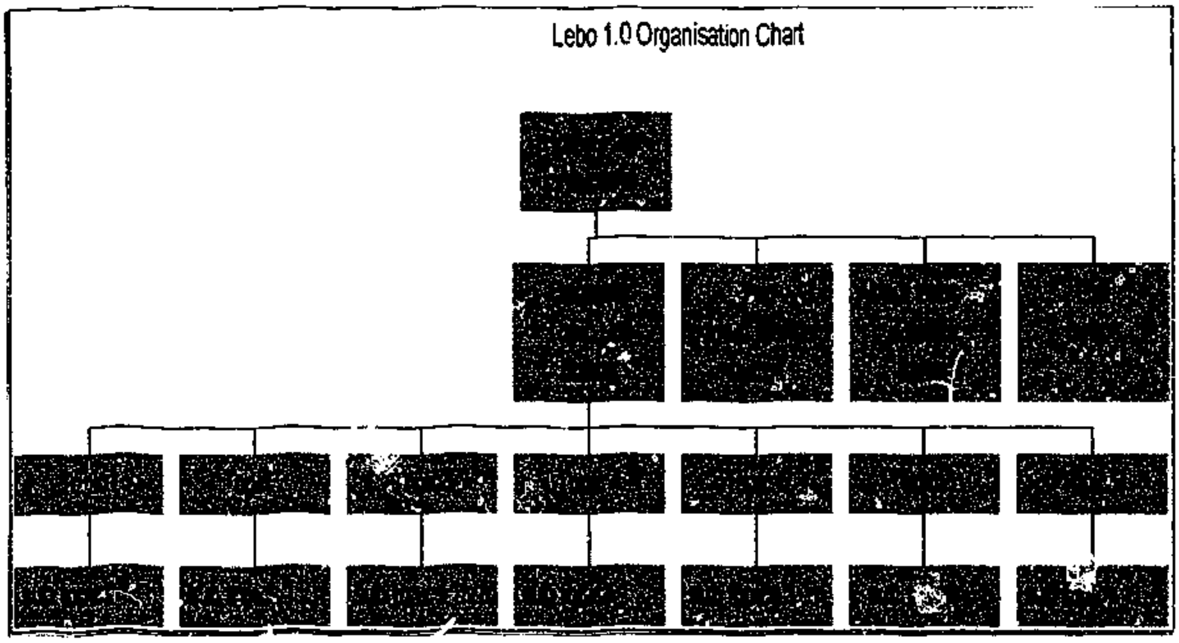
**Lebo 1.0 - An Interactive Mathematics 2 Project** was developed using the Director 6.5 programming software from Macromedia. It followed a didactic design that may be described as 'Drill and Practice' with some hypertext style functions incorporated into the design providing for an interactive approach to learning. Basically the 'Drill and Practice" design consists of some initial instructions followed by examples and exercises with feedback and or comments depending on the answer and finally a model solution. All steps in the design are structured in much the same way (Laaser, 1993).

The 'drill and practice' style of presentations were very popular in the early days of the PC but has also attracted substantial criticism more recently from critics, that it is not a very effective method of instruction in teaching higher order concepts in mathematics. Nonetheless the 'drill and practice' method of instruction has survived and is used extensively, albeit with better-developed and more versatile software with improved interfaces e.g. Monash University's First Year Mathematics software - Epsilon. Lebo 1.0 was designed applying concepts that were similar to Epsilon.

In Lebo 1.0 the examples were included in the software-based instructions but the students were referred back to the topic booklets for the exercises. Exercises were included in the software-based instructions in Lebo 1.5, which was the upgraded version of Lebo 1.0 used in the main study. One of the design objectives in developing the Lebo CAI software was to keep textual explanations as short and succinct as possible. The aim was to avoid overloading the students with long and convoluted textual explanations as much as possible. Navigation from page to page within the program was facilitated through simple navigation buttons, which were appropriately and clearly labelled. There were also hypertext-style, highlighted 'clickable' words or sentences, which could also be used for navigation purposes.

#### 4.3.2.3 The Organisational Structure of the Lebo 1.0 Software

*Figure 4.1: Organisational structure of Lebo 1.0.*




The user is taken to the "Home Page" at startup. In the Home Page the user has four options. The options are "Content", "Help", "About Lebo 1.0" and "Exit". Although there is an "Help" option, the feature was not completed at time of fieldwork mainly because of insufficient time. This was not a problem during the tutorials because the researcher was present in all the CAI tutorials and acted as the help feature for the software during the tutorials.

The "Content" button is the main option along which the user is expected to proceed. The "Content" button leads to the topics, which in turn lead to the subtopics. The subtopics contain the instructional content material, examples and exercises. The exercises are designed as interactive experiences Students are either required to input variables as required while completing the exercise questions or to supply answers to questions they calculate as correct. A button for evaluating the answer to the exercise questions is provided which when clicked either checks the answer the user supplies as correct with a tick mark [✓] or wrong with a cross [✖]. An option in the form of a button is also provided for the correct solution to the question which the student is able check.

The following points of similarity can be made in comparing the Lebo 1.0 organisational structure to the structure of the book-based materials. The topics in the Lebo software represent the topic booklets in the written materials and the sub-topics in the Lebo software represent the actual sub-topics in the topic booklets.

Navigation from concept to concept, and to and from examples and exercises within the sub-topics is facilitated by means of simple forward and back navigation buttons as well as 'clickable' words or phrases and other appropriately labelled buttons.

On every page in the software a "Quit" button labelled as such is featured prominently. This is designed to take the user to the "Home Page" from any page in the Lebo software to start allover again if he or she got hopelessly lost in navigating from page to page.

#### 4.3.2.4 The Operating Environment for Lebo 1.0 and the Time Required for Development

The software is designed to run on windows 3.1, 95, 98 and NT platforms as a standalone, executable application file that required only the operating system to run. The standalone nature of the software is an extremely crucial aspect of the software because portability is a very important objective in the design of the software. In its completed form the student is expected to be able to pick up a CD-ROM version of the software and be able to use it independently on any computer with a CD-ROM drive.

To develop any software to a fully functional stage, a lot of time and resources are required which the researcher did not have. Lebo 1.0 was developed over a period of about 8 months before it had to be used in the pilot study. This is not a lot of time considering that the first 3 months were spent learning the Director programming software before the Lebo 1.0 program development began. Prior to December 1998 the researcher had barely heard about the Director programming software from Macromedia and had never seen it in use at all.

Lebo 1.0 was developed and upgraded to Lebo 1.5 following the pilot study and before it was used in the main study. Due to the condensed development period, the software was used in the pilot study and the main study with only the first five out of the nine topics of mathematics 2 developed to a reasonably advanced stage for use by the experimental (CAI) group. The 5 topics developed were designed to take the students from the beginning of the semester through to the mid-semester assessment test (posttest) after 7 weeks of instructional time.

Following the pilot study it was decided to limit the period of actual data collection to just half the semester (7 weeks) instead of the whole semester as originally planned. There were two main reasons for this decision. One was related to the lack of sufficient time to develop the software to include all nine topics in the course as discussed above, the other was related to the attendance patterns of the students at CAI tutorial sessions discussed in section 5.4 in chapter 5.

#### 4.3.2.5 Demonstrating Lebo 1.0

**Lebo 1.0-An Interactive mathematics 2 project**, was demonstrated before two Monash University multimedia section experts at the Gippsland Campus of Monash University who commented that it was designed well and was appropriately programmed. Suggestions made at the demonstration on minor changes to the software for better clarity were incorporated. The modifications were mainly to do with the labels given to navigation buttons in the software.

It was noted that Lebo 1.0 had several strong features that facilitated a user-friendly learning environment in contrast to classroom-based FTF tutorials. A few of the more outstanding features of the software are listed below.

One strong point of Lebo 1.0 was that the students were seen to actually work individually and seen to progress quickly through their lessons in contrast to the usual classroom-based FTF tutorials in IDCE where students' progress is usually at the rate of the slowest learner. In contrast to the normal situation in FTF tutorials, it was easier to provide individual attention to student queries and more efficiently. It was also observed that the students went through the CAI lessons on their own and did not sit around waiting for the instructor to initiate proceedings, as is often the case with FTF tutorials in IDCE and in school classrooms in PNG generally. Consequently student queries were more focussed than is often the case in FTF tutorials. Tutor explanations did not require as much effort as is the case in FTF tutorials because of a better portrayal of the situation under consideration on the computer screen, providing a ready point of reference for the explanations.

Another strong feature of Lebo 1.0 was the immediate availability of solutions to examples and exercise questions at the click of a button providing quick and efficient feedback. The capability of Lebo 1.0 to immediately post a solution check in a window on the screen made referencing easier, a feature that was appreciated by the students.

Lebo 1.0 also incorporated colour, graphics and some animation, which provided emphasis to concepts being presented as well as facilitating automated demonstrations of mathematical processes and techniques such as in linear and parabolic graphing. The latter feature captivated the students' attention and appeared to help them in understanding concepts in the graphing of linear and parabolic equations.

Lebo 1.0 was also seen to facilitate quick and continuous revision of concepts in each of the five developed topics in the software.

#### 4.3.3 Research Instruments used in the Pilot Study

Listed below are the four instruments that were used in the process of data collection in the pilot study in fulfilling the aims of the present study.

1. Mathematics Attitudes Questionnaire (**MAQ**)
2. Computer Attitudes Questionnaire (**CSQ**)
    a) Pre-Computer Experience Questionnaire (**CSQ1**)
    b) Post-Computer Experience Questionnaire (**CSQ2**)
3. Mathematics Performance Test (posttest only)

The following sections describe in some detail each of the research instruments listed above.

##### 4.3.3.1 Mathematics Attitudes Questionnaire (MAQ)

The MAQ was originally designed as a 45 item, 5 point Likert scale to solicit attitudinal responses towards various aspects of mathematics. The main question the MAQ was designed to answer was whether Mathematics 2 students had significantly positive attitudes or poor attitudes to mathematics. The MAQ was considered necessary to get a better picture of the matriculation students' attitudes towards mathematics thereby providing a context for the students' performances in the posttest.

Another purpose was to determine whether there was a significant difference in attitudes to mathematics or otherwise between those who volunteered for the Computer-assisted Instruction (CAI) group and those consequently included in the Traditional Methods (TM) group. A difference demonstrated in the attitudes to mathematics by the two groups would lead to the conclusion that the sampling method used in creating the two samples was biased and therefore not valid.

The questionnaire was produced using a questionnaire and survey design software called "Personal Quest" version 1.6a from Dipolar Pty Ltd. of Australia [http://www.dipolar.com.au]. The questionnaire items were either generated by the researcher himself or were selected from several other sources. Of the other sources the following three were the main ones directly referred to in the design of the questionnaire in the present study. The first was the "Opinions of mathematics" questionnaire in the "Mathematics In-service Guidelines Study" of primary school teachers in non-metropolitan regions of Victoria by Dettrick (1981), which in turn was an adaptation of a mathematics attitudes scale by Aitken (1974). The second main source was the attitudes to mathematics questionnaire by Kaleva (1998) and the third was the attitudes to mathematics questionnaire by Kari (1998). Both of the latter two scales were developed for use in Papua New Guinea, with high school mathematics teachers and school students. Items from these sources were reworded in some cases with permission to suit the context of the present study from the point of view of the researcher.

The MAQ was designed to take between 10 to 20 minutes for the students to complete. The pilot study showed that this was approximately the correct timing for the completion of the questionnaire.

The responses were coded during data entry in such a way that the higher the median scores on the scale the more positive the student's attitude was meant to be towards a particular aspect of mathematics. This was accomplished by coding the responses according to whether the items were positively or negatively worded (see table 4.5 for the orientation of items) before data-entry. The response scales were Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD) and Not Sure (NS). The scale was arranged with the "NS" response in the middle of the scale regardless of the orientation of the item with a numerical code value of 3. The numerical code value given to each graduation in the scale in the pilot version of the questionnaire was SA = 5, A = 4, D = 2 and SD = 1 for positively worded items, and SA = 1, A = 2, D = 4 and SD = 5 for negatively worded items. The orientation of each item is shown by either a "+" or a "-" against the item in the questionnaire itself as shown in the frequency summary table (4.5). This design produced results, such that the higher the median scores the more positive was the attitude towards mathematics.

The MAQ was applied right across the total study sample, i.e. to both the experimental group (CAI) and the control group (TM), because it was the attitude towards mathematics of the total study sample that the researcher was interested in.

Reliability and validity considerations for the data from the MAQ are discussed in section 4.8.1 and 4.9.1.1 respectively.

#### 4.3.3.2 Computer Attitude Questionnaires: CSQ1 and CSQ2

The computer attitude questionnaire was designed as a pre-computer experience questionnaire (CSQ1) and a post-computer experience questionnaire (CSQ2). Both CSQ1 and CSQ2 were to be applied to the experimental (CAI) group only with CSQ1 administered before and CSQ2 at the end of the computer-based tutorials.

All the items in the two questionnaires were original items developed specifically for the present study by the researcher, and similar to the MAQ, the questionnaire and survey design software, Personal Quest, was used to produce them.

The purpose of the questionnaire was to ascertain student dispositions to computers and the various aspects of computer-based instruction such as interactivity, imagery - colour and graphics, rapid feedback and the capability of CAI to better provide for individualised learning. The resulting two questionnaires were not exactly the same but had 20 items which were common to both questionnaires for the purpose of comparing change in attitude after experiencing learning through CAI.

It was the intention to investigate whether such issues as interactivity, imagery - colour and graphics presentation, rapid feedback capability and the capability of CAI to provide for individualised learning made any difference to the students' attitudes towards learning via CAI or not.

The structure of the Likert scales in CSQ1 and CSQ2 were identical to that in the MAQ and the coding of the responses also proceeded very much along the same lines as that in the MAQ. Both the CSQ1 and CSQ2 had two sections: a section A and a section B. Section B in both questionnaires consisted of a Likert scale. Section A was general and very short in both cases but asked for responses to a different set of items in each case (see appendix P5 & appendix P9). The items in section A in CSQ1 consisted of a mixture of general response items (items 2 & 4) and Likert scale type items (items 3, 5, 6 & 7). Section A (item 1– 6) in CSQ2 consisted of Likert scale type general items.

Reliability and validity concerns for the two questionnaires, CSQ1 and CSQ2, are addressed in section 4.8.1 and 4.9.1 respectively.

#### 4.3.3.3 Mathematics Performance Test

The Mathematics Performance test was also designed as a pretest and a posttest to investigate differences and comparative change in student performances in mathematics between the CAI group and the TM group after undergoing instruction by two different modes of instruction. As mentioned in previous sections, the pretest aspect of the mathematics performance test was not implemented in the pilot study due to the problems encountered with logistics and insufficient time, therefore the test was applied only as a posttest. The posttest was administered across the total study sample i.e. to students in both the experimental (CAI) group and the control (TM) group.

The test administered as posttest in the pilot study was intended to be the same as the pretest except for the cover page and a rearrangement in the order of the multiple choice distracters in the answers between the pretest and the posttest. However this was not a consideration in the pilot study as only the posttest was applied.

The test was designed in a multiple-choice format for a quick, easy and objective assessment. The questions in the tests were typical test items in the mathematics 2 course and were fairly concentrated around the knowledge, comprehension and application areas of Bloom's Taxonomy of educational objectives which is typical of mathematics 2 course objectives. It was decided, based on the researcher's experience with teaching mathematics 2 students in the past, that the test would be based on the set syllabus as outlined in the first five of the nine course booklets that the students had. The questions were also intended to be typical of the mathematics 2 course even if it meant not testing higher order mathematical reasoning.

The posttest was designed and developed by the researcher specifically for the present study based on experience gained teaching the mathematics 2 course previously and is not based on any existing validated performance test.

The reader should note that it was never the intention of the researcher to change or modify the existing syllabus in any way at all for the sake of the study. The pretest (in the main study only) and posttest were going to test for performance in the existing Mathematics 2 syllabus whatever its perceived merits or faults.
The preceding considerations notwithstanding the significantly high correlation (see table 4.2 below) between the posttest and the final exam, which was not written by the researcher, showed that the questions in the posttest were typical assessment questions in the course as intended.

**Table 4.2: Correlation between the Posttest and the Final Examination**

| | | | M2FinalExResult |
|---|---|---|---|
| Spearman's rho | Score | Correlation Coefficient | .498** |
| | | Sig. (2-tailed) | .003 |
| | | N | 33 |

**. Correlation is significant at the .01 level (2-tailed).

** The "Score" in table 4.2 refers to the posttest score.

The results in table 4.2 also touch on the question of validity for the posttest. As far as the universe of content for the course went in reference to the specified syllabus the results of table 4.2 demonstrated validity i.e. the posttest was testing what it was supposed to test.

Concerns for the reliability of the test are addressed in section 3.8.2.

#### 4.3.3.4 Summary of Test Procedures and Specifications for the Posttest

1. Assess the state of mastery of mathematical concepts in 27.023 by the students after having gone through the course
2. Applied after 7 weeks of teaching in the course.
3. Designed as an hour and 55 minutes-long test.
4. Designed to measure any positive performance outcomes as a result of going through the course via CAI or TM.
5. Contained 40 multiple choice questions with each question worth 2 marks.

## 4.4 Justifying the Research Instruments

The main instrument used to meet the requirements of this study ie to demonstrate the efficacy of CAI in the Papua New Guinea context was the mathematics performance test (posttest). The other three instruments ie MAQ, CSQ1 and CSQ2 were focussed on the attitudinal backdrop or context within which the posttest was conducted. Basically the MAQ and CSQ1 questionnaires were probing the pre-existing attitudes towards mathematics and computers respectively that the students were taking into the research context. CSQ2 was probing attitudes students had developed as a result of exposure to computers and the research software. The discussion in this section is therefore focussed on the justification for the use of the mathematics performance test (posttest).

There were a number of ways in which this study could have proceeded. The present study adopted a quantitative approach in applying quantitative techniques in viewing and analysing data as in a quasi-experimental (Wiersma, 2000) study. Aspects of the qualitative approach of observation were also used to understand the ways students engaged with the study.

The difficulty of applying random selection in selecting the subjects for the samples in the study made the strictly experimental approach not feasible. At the same time it was felt that the best way to proceed in probing student performances before and after treatments in a mathematics course as was required in this study made it imperative that some aspects of quantitative testing were utilised. A strictly qualitative approach therefore would have been as inappropriate as an experimental approach and would have required more time and resources than the researcher had at his disposal. Furthermore the researcher lacked the necessary experience to adopt a strictly qualitative approach. Hence the approach chosen for this study was prescribed by the circumstances prevailing both in general and in the population chosen for the present study at the time.

The fundamental aim of the study was to investigate whether CAI is less effective, as effective or more effective than the more traditional models of instruction such as limited FTF teaching in mathematics and course booklets, in the Papua New Guinea distance education context. Hence an approach which gave relevant performance data after teaching, for the sample using CAI and the sample using traditional approaches, was appropriate.

## 4.5 Sampling Parameters of the Research Population

### 4.5.1 Sampling Method

The choice of the UPNG Main Campus as the site for the study was due to the availability of computer resources at this site as mentioned earlier, and because it was then possible for the researcher to be involved directly with all aspects of the conduct of the study. Once the site was chosen it followed that the study sample had to be selected from the mathematics 2 students at the main centre only. The application of random sampling in selecting the site was therefore not an option because only the main centre had the necessary facilities to accommodate the present study.

The convenience samples sampling method (Fink and Kosecoff (1998: pp. 44)) was the main method that was employed in selecting participants in the pilot study from the study sample. Sixty-three students in total completed and provided personal information required by the researcher to facilitate the necessary statistical analysis of the questionnaire data. The sixty-three students were also the only students who completed and returned MAQ questionnaires.

Selection into treatment groups was effected through students volunteering for the CAI (experimental) group and the rest being designated members of the TM (control) group. The TM group also included students who were not in the group of sixty-three students who provided personal information and completed MAQ questionnaires.

The researcher was fully aware of the higher probability of introducing bias in sampling using the method of convenience sampling but this was considered acceptable in the pilot study. Moreover, the method of convenience samples sampling was in fact the only sampling method that could be employed in the pilot study given the dynamics of the research population as well as the problems encountered in implementing the pilot study. Some attempt was made in the main study to apply random sampling in selecting students for the treatment groups but this proved rather difficult and was not entirely successful. This is described further in the main study in chapter 5.

Some students who initially indicated a willingness to participate in the pilot study by volunteering for the CAI group lost interest in the project because of the long delay in starting the pilot study due to the late installation of the CAI software. This situation had the effect of reducing the sample sizes even further. The problem of the small sample sizes is considered further in the discussion of the results of the pilot study.

### 4.5.2 Sample Population

The sample population for the pilot study was the semester 2, 1999 student cohort enrolled in the mathematics 2(27.023) course in the adult matriculation program of IDCE at the main centre only. (In the main study the semester 1, 2000 cohort was used.) This group was chosen because it was the largest intact group of all the University Centres in the country and was also the most easily accessible group to the researcher. In addition it was based in the national capital of Papua New Guinea, to which people move from all over the country, it would therefore be expected to contain a cross-section of the national population.

Students enrolled in mathematics 2 had typically completed the pre-requisite, mathematics 1 (27.022) course besides fulfilling the other requirements for entry into the adult matriculation program, such as the completion of at least a grade 10 level of general education. A few students had completed grade 11 or 12 and a very small group had gained entry through other adult entry criteria. Some of the students in the sample population had also attended other post-grade 10 tertiary institutions with some having qualified as professional people in various occupations such as in teaching and nursing (see table 4.3).

The following section describes the two treatment groups and the different instructional procedures that each treatment group was subjected to.

### 4.5.3 Research Groups

#### 4.5.3.1 Group 1 - Experimental (CAI) Group

This group met with their tutor once a week for up to two hours in the CSU computer laboratories. Members of this group went through their lessons using the Lebo1.0 mathematics 2 software (see section 4.3.2 for a full description of Lebo1.0) in a self-directed, interactive manner. The tutor was only present to assist them with computer operations-related problems and software usage-related problems as the students went through their lessons on the computer on their own. The tutor also discussed individual mathematics-related problems that a student initiated himself or herself.

The CAI students were not required to be present at the tutorial sessions for the entire two hours of booked time, but they were requested to accumulate a total contact time at each session of not less than one hour. This was basically the effective teaching time that normally prevails even in the usual two-hourly FTF sessions.

Initially it was expected that all students in the CAI sample would have had a basic familiarity with the use of computers. This expectation as it turned out in both the pilot study and the main study was over-optimistic as more than 50% of the CAI student sample indicated that this was their first or very close to their first experience with computers. Some initial basic training in the use of computers was incorporated into the research project at the beginning of the course. The main computer skill that the CAI students needed was the ability to handle the computer mouse competently. The CAI software was designed around the students' ability to use the mouse, with every operation possible in the software simply a mouse-click away. The use of the keyboard was pitched at a very rudimentary level mainly to input single key values for variables in solving mathematics questions in the examples and exercises.

#### 4.5.3.2 Group 2 - Control (TM) Group

It is important to note here that the usual teaching approach, termed in this study Traditional Methods (TM), involves limited (2 hours per week) face-to-face tutorial, self-study and text. Self-study refers to the situation where students do not attend any tutorials at all but learn the materials on their own in their own time and text refer to the course text.

The TM group was also scheduled to meet with their tutor once a week for a two - hour session, as is the usual practice in the course. There was no real need to restrict or control the numbers of students in this group because this group included everybody else that was not in the CAI group including those students not in the group of sixty-three students who completed and returned MAQ questionnaires.

### 4.5.4 The Research Population Characteristics

The research population for the pilot study was taken as the student cohort of semester 2, 1999 enrolled in the adult matriculation course mathematics 2. This is a part of the larger adult matriculation population of IDCE. A typical student enrolled in the mathematics 2 course is described in table 4.3 below.

The points in table 4.3 are brief summaries of the information contained in the summary tables on population demographics in appendix P1 obtained from the personal information survey. These tables provide a useful descriptive summary of the typical student who is most likely to be enrolled in the mathematics 2 course in any semester as subsequent data obtained in the main study confirmed.

Although these summaries were from data obtained from students based at the main centre only, based on a reasonable knowledge of the AM population of IDCE it can be confidently concluded that they were representative of all mathematics 2 students enrolled in semester 2 of 1999. Furthermore since the semester by semester intake into the AM program is basically from a similar population the summaries would also be generally representative of all students enrolling in the mathematics 2 course each semester.

*Table 4.3: Summary of Population Characteristics*

| **Pilot Study (semester 2, 1999 cohort)** |
|---|
| • **75%** of the sample was in the 18-24 years age group |
| • **81%** of the sample was male |
| • **81%** of the sample had enrolled in the Adult Matriculation program, of which the course mathematics 2 was part, after completing grade 10 |
| • Although students who did grade 10 as far back as 1981 were in the sample most had completed grade 10 within the last 5-6 years |
| • About **32%** of the sample had attended some form of tertiary education |
| • About **30%** of the sample were repeating the course mathematics 2 |
| • At least **30%** of the sample listed a trade or occupation. |
| • About **32%** of the sample were employed |

From the summary provided above the following general points can be made about the research population. More than 70 percent of the students were young adults not too long out of school and almost all of them had, had at least a grade 10 level of education. The population was also overwhelmingly male and a significant proportion of the population had also had some form of professional training. Table 5.1 in chapter 5 provides a comparison of the pilot statistics with those obtained in the main study for semester 1, 2000.

## 4.6 Pilot Study

The pilot study was conducted in the second semester of 1999 at the Main Campus of UPNG. The second semester at UPNG extends from the beginning of July to the end of October. The pilot study itself was conducted from early September to the end of October. The CAI tutorials in the pilot study were conducted over a period of only four weeks. They were started 8 weeks into the semester and finished abruptly a week earlier than planned. The original plan, with time on hand, was to conduct the pilot study as a miniature version of the main study in its entirety, but this plan was adjusted to fit in with the circumstances at the University at the time. The two main problems encountered in the pilot study were the late installation of the CAI software and a University-wide student strike towards the end of the pilot study. The late installation was due to the UPNG Computer Systems Administrator's sudden departure on recreation leave, just as the researcher arrived at the UPNG Main Campus. No other Computer Services Unit (CSU) staff had the necessary authority or skill to install the CAI software in the networked computers in the Systems Administrator's absence. The Systems Administrator returned more than half way through the semester and installed the CAI software, leaving the researcher only five weeks in which to conduct the CAI tutorials for the pilot study. The students' strike then disrupted the CAI tutorials abruptly at the end as classrooms and laboratories were picketed effectively cutting the duration of the pilot study to just four weeks.

Regardless of the problems documented above sufficient data were collected to analyse the important aspects of the instruments used. However, the shortened period for the pilot study forced on the researcher by circumstances meant that the plans had to be modified. Instead of the planned miniature version of the main study for the pilot study, only some aspects of the instruments were tested in the pilot study. The modifications are described in the relevant sections with discussion on how they differed from the main study.

The four instruments described in section 4.3.3 were used in collecting the research data in the pilot study. The instruments were the MAQ – the mathematics attitude questionnaire, CSQ1 - the pre-computer experience questionnaire, CSQ2 - the post-computer experience questionnaire and the Posttest - the mathematics performance test. In the main study described in chapter 5 there was also a pretest before the instruction in the course began which was not implemented in the pilot study because of the logistics problems encountered.

Table 4.4 below is the implemented data collection timetable given all the factors that impacted on the period of the fieldwork in the research.

*Table 4.4: Actual Research Plan Followed*

| Duration | Activity |
|---|---|
| Dec 98 - Apr 99 | Preparation of research Instruments: CAI Software, MAQ, CSQ1, CSQ2, Pretest and Posttest |
| May 99 - Oct 99 | Piloting of Research Instruments. |
| Nov 99 - Dec 99 | Follow-up work on the pilot study and necessary modification of the instruments following the pilot study. |
| Jan 00 - Mar 00 | Data Collection Activities: Research Teaching, Application of pretest, MAQ and CSQ1 at beginning and application of CSQ2 and Posttest at end. |
| Apr-00 | Follow-up work on the data collection activities and data entry. Return to Monash. |

### 4.6.1 Location and Physical Facilities used in the Research

There are a number of computer laboratories at the Main Campus of UPNG. The CAI tutorial sessions were conducted in two general CSU computer laboratories that together contained 36 computers. The computers in the two laboratories were all networked IBM compatibles, with a Windows NT operating system environment. The CAI software worked well in the two laboratories under the Windows NT environment.

### 4.6.2 Tutorial Sessions conducted in the Pilot Study

A number of CAI tutorial sessions were scheduled each week to allow the CAI students some options with their individual timetables. Consequently each tutorial session was conducted on a separate day at various times of the day to cater for the needs of various student groups. For instance there was an after-hours tutorial session for students who were employed and could only make it to the tutorials after working hours.

The CAI tutorial sessions were planned so that there was one student to a computer at each session, therefore as many students as there were computers were fitted into each tutorial session. Each student was allowed attendance at only one CAI tutorial session per week in keeping with the usual level of FTF sessions normally available to each student in the course. An attendance record was kept for the CAI group.

There were also a number of tutorial sessions conducted for the TM group but these tutorials were supervised directly by the Mathematics Coordinator of IDCE and not the researcher. The researcher was kept informed of the progress of the TM tutorial sessions. TM students were also allowed attendance at only one FTF tutorial session per week, as is the usual practice. An attendance roll was not kept for the TM students because it was not considered necessary.

Each tutorial session for both groups was 2 hours in length with an estimated effective contact time of just over an hour.

### 4.6.3 Data Collection Procedures

1. The mathematics attitude questionnaire (MAQ) was given to students enrolling for Mathematics 2 (27.023) at registration time. The MAQ was bundled together with the questionnaire for personal information as the first part of the questionnaire package. Students were allowed to complete the MAQ right up to the end of the pilot study in order to get as many students as possible to complete and return the questionnaire. It was immaterial when during the semester the students completed the MAQ questionnaire because the researcher was of the opinion that students already had an established attitude to mathematics by the time they enrolled for mathematics 2. Students completed the MAQ entirely on a voluntary basis in the pilot study.

2. Students enrolling in mathematics 2 at the Main Campus were streamed into two tutorial mode groups for instructional purposes. From the sample of 63 that responded to the MAQ, a sample of 40 students volunteered for the CAI (experimental) group. The rest of the students enrolling for mathematics 2 were then included in the Traditional Methods (TM) group. These students did their lessons in the usual way i.e. through a mixture of self-study and attendance at FTF tutorial sessions.

3. Those who volunteered to undergo instruction via CAI then completed a Pre-Computer Experience Questionnaire (CSQ1) before the 4-week period of instruction began.
4. A 4-week period of instruction was then conducted: CAI students in the computer laboratory and TM students in classroom-based FTF tutorials.
5. At the end of the 4 weeks of instructional time the posttest was administered to all mathematics 2 students in both groups.
6. The CAI students also completed the post-Computer Experience Questionnaire, CSQ2, at the end of the 4-week period of instruction.

It was originally planned to set up a mini computer laboratory in the IDCE annex for those CAI students who were not able to attend set tutorial times in the main computer laboratories but this did not eventuate because of a lack of computer resources in IDCE. The problem of non-attendance at tutorial sessions the above measure was meant to solve was then taken care of in the main study by the decision to analyse the results by number of tutorial sessions attended by each of the CAI students.

All survey questionnaire forms were hand-delivered to the students and were either collected back from the students during tutorial times or were returned by the students themselves to the researcher either in person or posted to the researcher's staff pigeonhole. Throughout the period of data collection the researcher was available to all (both CAI and TM) students in his office for consultation most times during normal working hours, when not involved in CAI tutorials.

## 4.7 Descriptive results from the Pilot Study

This section presents the descriptive results from the application of the four instruments described in section 4.3.3 used to collect data in the pilot study.

In almost all the statistical analyses the statistical package SPSS version 9.0 was used. The reason for using version 9.0 instead of 10.0 is historical. The researcher did not have access to version 10.0 until after results analysis had been in progress for some time. Version 10.0 was used later to check the analyses again at the end. Apart from the differences in the interface, SPSS versions 9.0 and 10.0 were much the same in the analysis results they produced and there is a somewhat seamless transition from version 9.0 to version 10.0.

### 4.7.1 Instrument 1 - MAQ Results

A copy of the Mathematics Attitudes Questionnaire (MAQ) used in the pilot study appears in appendix P2. The MAQ was a 45 - item questionnaire with a 5-point Likert scale. Its purpose was to probe the adult matriculation students' attitudes to mathematics, as a means towards contextualising their performances in mathematics (posttest and final examination).

The main results obtained from the administration of the MAQ were frequency summary tables and a summary statistics table, which provided some indication of the attitudes of students in the study sample. Results on statistical tests of hypotheses are described in section 4.11. Table 4.5 below is a summary of the response frequency summaries for the MAQ Likert scale.

It is quite clear from table 4.5 that students in the research population had a decidedly positive attitude to mathematics. But while this is the case in general the table also shows clear evidence of uncertainty in the student responses indicated by a significantly high percentage of students responding "NS" (Not Sure) in a number of items. In particular items 4, 5, 12, 13, 19, 22, 23, 24, 26, 28, 29, 32, 37, 41, 42 and 45, about 40% of all items, showed a significantly high percentage ($\geq 15\%$) of "NS" responses. Of these items, items 4, 5 19, 22, 23, 24, 28, 41, 42 and 45, about 20 percent of the items, showed uncertainty levels of twenty percent or more.

On focussing on the ten items showing uncertainty levels of twenty percent or more, it was found that seven of these items are on the relevance of mathematics in the cultural context.

There appears to be a clear level of uncertainty about the relevance of mathematics in the cultural context while at the same time affirming the importance of mathematics in general.

*Table 4.5: Frequency Summary Table for the MAQ Likert Scale - Pilot Study*

| # | Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 1 | Doing mathematics is a challenge I enjoy. | 93 | 2 | 5 | + |
| 2 | Mathematics is so useful that it should be a required part of my professional skills. | 95 | 5 | 0 | + |
| 3 | I don't like mathematics because it is not relevant to my traditional culture. | 5 | 11 | 84 | - |
| 4 | Pre-University mathematics as it is taught at present is too foreign and not applicable to PNG students. | 8 | 21 | 71 | - |
| 5 | Pre-University mathematics is too divorced from PNG traditions and culture. | 6 | 32 | 62 | - |
| 6 | I get a great deal of satisfaction out of solving a mathematics problem. | 94 | 0 | 6 | + |
| 7 | There is no use for mathematics in PNG traditional culture. | 3 | 10 | 87 | - |
| 8 | It takes me a long time to understand a mathematical concept. | 48 | 10 | 42 | - |
| 9 | Mathematics is important for me to learn whether it is relevant to PNG traditional culture or not. | 98 | 2 | 0 | + |
| 10 | Mathematics will be useful to me in my profession. | 97 | 3 | 0 | + |
| 11 | I would like to study advanced mathematics. | 89 | 11 | 0 | + |
| 12 | The thought of taking another mathematics course makes me sick. | 2 | 18 | 80 | - |
| 13 | I find mathematics to be very logical and clear. | 68 | 16 | 16 | + |
| 14 | I have always enjoyed studying mathematics. | 89 | 3 | 8 | + |
| 15 | Mathematics is necessary to keep the world running. | 84 | 13 | 3 | + |
| 16 | Mathematics is not important in everyday life. | 3 | 5 | 92 | - |
| 17 | Mathematics has contributed greatly to science and other fields of knowledge. | 98 | 0 | 2 | + |
| 18 | I am interested and willing to acquire further knowledge of mathematics. | 94 | 6 | 0 | + |
| 19 | Mathematics identified in traditional cultural activities should also be taught in pre-University mathematics. | 65 | 30 | 5 | + |
| 20 | Mathematics helps to develop a person's mind and teaches him or her to think. | 94 | 6 | 0 | + |
| 21 | I am able to figure out most of the equations I need to solve a mathematics problem. | 73 | 13 | 14 | + |
| 22 | The pace of a mathematics course is so fast that it is impossible for the average student to learn the subject matter thoroughly. | 60 | 20 | 20 | - |
| 23 | Mathematics ideas exist in my home culture. | 60 | 26 | 14 | + |
| 24 | Methods of solving mathematics problems are useful in my home culture. | 55 | 32 | 13 | + |
| 25 | Mathematics is about useful and practical ideas. | 95 | 5 | 0 | + |
| 26 | I should be allowed to choose whether to study mathematics or not. | 62 | 18 | 21 | + |
| 27 | Mathematics is very interesting and I have usually enjoyed courses in this subject. | 96 | 2 | 2 | + |
| 28 | There are no useful mathematical ideas in traditional cultural activities. | 8 | 41 | 51 | - |
| 29 | I enjoy going beyond the stated course and trying to solve new problems in mathematics. | 77 | 18 | 5 | + |
| 30 | I would like to develop my mathematics skills and study this subject more. | 95 | 5 | 0 | + |
| 31 | An understanding of mathematics is needed by artists and writers as well as scientists. | 92 | 6 | 2 | + |
| 32 | Mathematics is less important to people than art or literature. | 11 | 16 | 73 | - |
| 33 | There is nothing creative about mathematics, its just memorising formulae and things. | 30 | 6 | 64 | - |
| 34 | Mathematics is needed in designing practically everything. | 89 | 8 | 3 | + |
| 35 | Mathematics is dull and boring because it leaves no room for personal opinion. | 3 | 14 | 83 | - |
| 36 | I have never liked mathematics and it is my most dreaded subject. | 6 | 3 | 91 | - |
| 37 | Mathematics makes me feel uneasy and confused. | 21 | 16 | 63 | - |
| 38 | Mathematics is a worthwhile and necessary subject. | 95 | 3 | 2 | + |
| 39 | Mathematics makes me feel uncomfortable and nervous | 22 | 10 | 68 | - |
| 40 | I do not need mathematics to survive in the village. | 13 | 13 | 74 | - |
| 41 | Mathematics is useful in traditional societies. | 56 | 31 | 13 | + |
| 42 | I would avoid mathematics completely if that was possible and I could still continue my studies. | 7 | 20 | 73 | - |
| 43 | Mathematics is unnecessary in my chosen profession. | 3 | 8 | 89 | - |
| 44 | There are so many mathematical concepts to learn that I get confused. | 68 | 5 | 27 | - |
| 45 | Given the opportunity, I would take another mathematics course even though it were not required. | 10 | 20 | 70 | + |

Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree

The only item in which there were almost as many students agreeing as disagreeing was item 8 (*It takes me a long time to understand a mathematical concept*). The students' response pattern was most probably a reflection of the reality of the difficulty of mathematics as a subject.

The MAQ Likert scale (overall) was also subjected to Cronbach's Alpha reliability test, as reported in appendix P3, to determine whether there was any basis for the summation of the scale scores. The analysis shows that the overall measure of internal consistency for the 45 items of the MAQ was 0.86, which was well above the critical value of 0.7 and the scale was therefore accepted as internally consistent. This also provided a valid basis for the generation of the summary statistics as reported in appendix P4 for the pattern of responses in the MAQ.

The summary statistics confirm the rather marked positive attitudes of the students in the sample that were also observed in the response frequency summaries reported in table 4.5. All items except Items 8, 22 and 44 had medians of 4.0 or more in a scale from 1 to 5, implying a positive attitude to mathematics. This is further confirmed by a median of 4.0 for the overall view of mathematics taken over all 45 items as shown in table 4.6 below.

***Table 4.6: General Statistics for the Overall View of Mathematics Scale***

**Statistics**

Overall view of Mathematics

| N | Mean | Median | Std. Deviation |
|---|---|---|---|
| 63 | 4.0145 | 4.0222 | .3279 |

The median was chosen as the measure of central tendency for the data from the instruments in the present study, because of the ordinal nature of the data for which non-parametric analysis is more suitable. The median is a more suitable measure of central tendency in non-parametric analysis than the mean which is the conventional measure of central tendency in parametric statistics (Dettrick, 1997). The choice of the median as the preferred measure of central tendency in the present study notwithstanding, table 4.6 shows that there is very little difference between the two measures of central tendency in this case.

### 4.7.2 Instrument 2 – CSQ1 Results

A copy of this questionnaire appears in appendix P5 and the response frequency summaries for section A, (items 3, 5, 6 & 7) are reported in appendix P6. The response frequency summaries for the CSQ1 Likert scale (Section B) are summarised and reported in table 4.7 below.

CSQ1 and CSQ2 were questionnaires on the attitudes of students in the CAI sample to the use of computers and the CAI software in learning mathematics. CSQ1 was given to students who had volunteered for CAI tutorials and actually turned up for the first CAI tutorial session. It was given before the students had started working with computers. Although up to 40 students volunteered for the CAI tutorials, only those who actually turned up for the first CAI tutorial session and completed a posttest at the end, were recognised as CAI students for results analysis purposes.

CSQ1 consisted of two sections, a section A and a section B. Section A had one general item requiring the students to write a brief statement on the reasons for volunteering for the CAI class and five items that were designed to draw out information concerning the students' past experience with the use of computers. Section B consisted of 28 items on a 5-point Likert scale on the attitudes of the students to the use of computers and the CAI software.

Item 2 in section A of CSQ1 which asked the students to state their reasons for volunteering for CAI produced all kinds of responses which were found too difficult to code. Almost all students in Papua New Guinean educational institutions are second or third language English speakers and this factor alone contributed substantially to the difficulty in making sense of the responses as anything else. Furthermore a response to this item made sense only in the context of the pilot study anyway, not in the main study. In the main study attempts were made to randomly assign students to the treatment groups which invalidated this item. The item was therefore disregarded in the analyses because of the different sampling methods employed in the pilot and the main study. The appearance of the item in the main study version of CSQ1 was the result of an oversight; it should have been removed after the pilot study.

The extent of the students' response to item 3 (*I have used a computer before*) was rather unexpected and was in the end the determining factor on how the analysis of both CSQ 1 and CSQ 2 questionnaire data proceeded in the main study.
The responses to Item 3 shows that at least 65 % of the CAI sample had none to very minimal experience with computers prior to this study. The researcher was aware of the possibility that many students could be using the computer for the first time in the present study but not to the extent as shown by the response to the item.

Given this situation it was difficult to see how the students would have formed reliable or valid attitudes to computers and the CAI software as expressed in their responses to the items in the Likert scale.

Item 4 was directly related to item 3 in that the students who had used computers before were asked to indicate the context in which they had used computers. Four options were provided for the students to choose. The options were computer applications such as word processing, computer games, computer course and "other", which they were required to specify. In some ways this item was a repetition of item 3 because a further option required the student to indicate again if this was their first experience with computers or otherwise. In view of the response to item 3, this item was also ignored in the analysis.

Appendix P6 shows that only about 20 percent of the CAI students found the use of the mouse difficult but in contrast to this about 50 percent of the students found the use of the computer keyboard difficult. Reading text on-screen was not reported to be a problem by the majority of the CAI students.

The results in the pattern of difficulty on the use of the mouse and the keyboard was anticipated, as discussed in section 4.5.3 and addressed in the software design.

Table 4.7 below is a summary of the frequency summary tables for the 28 items in the CSQ1 Likert scale. There are roughly equal numbers of positively worded and negatively worded items.

*Table 4.7: Frequency Summary Table for the CSQ1 Likert Scale – Pilot Study*

| # | Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 9 | It is easier to read a line of text on a page in a book than on the screen. | 31 | 15 | 54 | - |
| 10 | Computers can help me improve my understanding of mathematics. | 77 | 23 | 0 | + |
| 11 | Computers are valuable tools for learning. | 92 | 8 | 0 | + |
| 12 | The world would be better off if computers have never been invented. | 12 | 11 | 77 | - |
| 13 | Learning mathematics using CAI is quicker and more efficient. | 65 | 31 | 4 | + |
| 14 | Learning mathematics through CAI lacks the sense of presence that a human tutor provides. | 42 | 27 | 31 | - |
| 15 | I would rather attend face-to-face tutorials with a human tutor than go through CAI. | 15 | 35 | 50 | - |
| 16 | More IDCE courses should be taught through CAI. | 69 | 19 | 12 | + |
| 18 | I joined CAI classes in mathematics 2 out of curiosity rather than because I think it is better than face-to-face tutorials. | 54 | 35 | 11 | - |
| 19 | I joined CAI classes because it was a chance to use and handle computers and not really to learn mathematics. | 50 | 15 | 35 | - |
| 20 | CAI can be a very useful way of learning mathematics if it is properly applied. | 92 | 4 | 4 | + |
| 21 | The time is right for computer applications like CAI in Papua New Guinea. | 84 | 4 | 12 | + |
| 22 | CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorials. | 23 | 23 | 54 | - |
| 23 | CAI cannot work in PNG because Papua New Guineans lack computer skills. | 20 | 15 | 65 | - |
| 24 | Learning mathematics through the medium of CAI is necessary. | 96 | 4 | 0 | + |
| 25 | CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | 4 | 4 | 92 | - |
| 26 | CAI is better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | 54 | 23 | 23 | + |
| 27 | Learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | 77 | 19 | 4 | + |
| 28 | What's the big deal! CAI, books or other modes of learning mathematics, they are all the same. | 42 | 31 | 27 | - |
| 29 | CAI is invented by people who are only interested in developing a commercial product. | 12 | 19 | 69 | + |
| 30 | If I had a computer I would definitely use CAI to study mathematics 2. | 92 | 4 | 4 | + |
| 31 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through these mediums. | 0 | 12 | 88 | - |
| 32 | I can learn mathematics better from a book in front of me than from a computer screen. | 11 | 35 | 54 | - |
| 33 | CAI is more effective in mediating learning in mathematics 2 than course booklets. | 46 | 42 | 12 | + |
| 34 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | 100 | 0 | 0 | + |
| 35 | I would like to learn how to use the computer more effectively. | 100 | 0 | 0 | + |
| 36 | CAI is less effective in mediating learning in mathematics 2 than course booklets. | 19 | 35 | 46 | - |
| 37 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | 38 | 24 | 38 | - |

Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree

The pattern of responses in the table very much reflects the lack of exposure to computers noted in the responses to item 3. There is a rather high percentage of "NS (Not Sure)" responses by the students to many items in the Likert scale as well as apparent inconsistencies in the response patterns. Items 10, 13, 14, 15, 18, 22, 26, 28, 32, 33, 36 and 37, i.e. about 40 percent of the items in the CSQ1 Likert scale, had "NS" responses of 20 percent or more recorded. Of these, items 13, 15, 18, 28, 32, 33 and 36, about a quarter of all items, had "NS" responses of greater than 30 percent.

There was also a lack of a clear-cut tendency in response patterns in about a third of the items, where there were almost as many students agreeing as disagreeing.

In this situation it was difficult to identify any attitudinal tendencies that the student sample had towards the use of computers in general or CAI.

In general therefore while students were keen to have a go at using computers in mathematics learning they were not sure how or in what ways computers were helpful to them in learning mathematics.

Their keenness to learn to use computers was most likely due to the vast publicity about computers that exists in the various media in PNG and the novelty aspect of learning to use them.

The scale of 28 items in the CSQ1 Likert scale was subjected to Cronbach's Alpha reliability test, as reported in appendix P7. The overall measure of internal consistency for the 28 items of the CSQ1 was 0.79, which falls above the critical value of 0.7 thereby providing some support to the reliability of the overall scale as a measure of a construct.

On the basis of this level of reliability, summary statistics as reported in appendix P8 were produced. These show that the students had positive attitudes to computers in general, as shown by the median (see earlier section on the reasons for using the median rather than the mean) value of each item. Except for item 16 all other items had median measures of 3.0 or above implying a generally positive attitude. Of course this has to be understood within the confines of the reservations already expressed in regard to the students' lack of adequate exposure to computers.

#### 4.7.3 Instrument 3 – CSQ2 Results

A copy of this questionnaire appears in appendix P9 and the frequency summary tables for each item in this questionnaire were summarised and reported in appendix P10 (section A) and table 4.8 (section B) below. CSQ2 was given to students at the end of the pilot study i.e. four weeks into the CAI tutorial sessions.

CSQ2 also consisted of a section A and a section B. Section A consisted of 6 general items on their basic computer skills level (items 1-3) and how the students felt about the CAI experience (items 4-6) having undergone four weeks of computer-based tutorials. Section B consisted of 36 items in a 5-point Likert scale on students' attitudes after the 4-week CAI tutorial experience.

Items 1, 2 and 3 (appendix P10) in CSQ2 were similar to items 5, 6 and 7 (appendix P6) in CSQ1 on the use of the mouse (Item 1) and keyboard (Item 2) and the comparative ease of reading a line of text on-screen (Item 3). Generally the pattern of responses on these items was similar in the two questionnaires. In CSQ 2 only about 5 percent of the students found the use of the mouse difficult in contrast to about 20 percent in CSQ1, but roughly the same percentage (about 50 %) found the use of the keyboard difficult to very difficult. This was expected as very little practise was provided in using the CAI software for improving keyboarding skills, whereas the students had many practises with using the mouse. Very few found the reading of text on-screen difficult.

The researcher's own observations during the CAI tutorials suggested that many students did not have much experience with computers from the way they handled the mouse and the keyboard at the start. But it was also observed that students picked up those skills quickly and by the end of the 4 weeks of tutorials they were reasonably comfortable in using the mouse in particular, and the keyboard, to the skills level required.

In response to item 4 (*Were the CAI lessons easy to use?*) and item 5 (*Were you happy with the amount of control you had over the CAI lessons?*) about 90 percent responded in the affirmative to both items. Further, in item 6 (*Do you think you learn faster or better on the computer?*) about 80 percent thought they learned faster and better in the computer-based tutorials.

In view of the response patterns in these items therefore and regardless of how these responses may be interpreted, the overwhelming conclusion is that students, in the CAI group at least, viewed the use of computers for learning mathematics extremely positively. This conclusion is also supported generally in the response patterns in the Likert scale.

Table 4.8 below is a summary of the response frequency summary tables for the thirty-six items in the CSQ2 Likert scale.

*Table 4.8: Frequency Summary Table for the CSQ2 Likert Scale – Pilot Study*

| # | Questionnaire Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 7 | It is easier to read a line of text on a page in a book than on the screen. | 25 | 20 | 55 | - |
| 8 | Computers can help me improve my understanding of mathematics. | 90 | 10 | 0 | + |
| 9 | The CAI-based mathematics 2 course has helped me improve my understanding of the contents of the course. | 85 | 15 | 0 | + |
| 10 | Computers are valuable tools for learning. | 100 | 0 | 0 | + |
| 11 | The world would be better off if computers have never been invented. | 10 | 30 | 60 | - |
| 12 | Learning mathematics using CAI is quicker and more efficient. | 90 | 5 | 5 | + |
| 13 | I would take another mathematics course through CAI after this experience. | 85 | 15 | 0 | + |
| 14 | Learning mathematics through CAI lacks the sense of presence that a human tutor provides. | 55 | 20 | 25 | - |
| 15 | I would rather attend face-to-face tutorials with a human tutor than go through CAI again. | 45 | 30 | 25 | - |
| 16 | More IDCE courses should be taught through CAI. | 80 | 15 | 5 | + |
| 17 | Learning mathematics through CAI is much better than learning it from course booklets. | 70 | 20 | 10 | + |
| 18 | CAI can be a very useful way of learning mathematics if it is properly applied. | 100 | 0 | 0 | + |
| 19 | The time is right for computer applications like CAI in Papua New Guinea. | 100 | 0 | 0 | + |
| 20 | CAI as a mode of learning in distance education in PNG should be pursued more vigorously. | 100 | 0 | 0 | + |
| 21 | CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorial. | 30 | 10 | 60 | - |
| 22 | CAI cannot work in PNG because Papua New Guineans lack computer skills. | 5 | 20 | 75 | - |
| 23 | Learning mathematics through CAI is necessary. | 100 | 0 | 0 | + |
| 24 | CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | 5 | 10 | 85 | - |
| 25 | CAI is better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | 65 | 15 | 20 | + |
| 26 | Learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | 95 | 0 | 5 | + |
| 27 | What's the big deal! CAI, books or other modes of learning mathematics, they are all the same. | 60 | 20 | 20 | - |
| 28 | I would like to learn how to use the computer more effectively. | 100 | 0 | 0 | + |
| 29 | Computers can really make one's life more difficult. | 0 | 5 | 95 | - |
| 30 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through these mediums. | 10 | 5 | 85 | - |
| 31 | I can learn mathematics better from a book in front of me than from a computer screen. | 15 | 25 | 60 | - |
| 32 | CAI is more effective in mediating learning in mathematics 2 than course booklets. | 55 | 25 | 20 | + |
| 33 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | 100 | 0 | 0 | + |
| 34 | I would like to learn how to use the computer more effectively. | 100 | 0 | 0 | + |
| 35 | CAI is less effective in mediating learning in mathematics 2 than course booklets. | 10 | 25 | 65 | - |
| 36 | Mathematics comes alive when taught through CAI. | 80 | 15 | 5 | + |
| 37 | I can see relationships and concepts in mathematics through the medium of CAI that I couldn't see before using books only. | 85 | 5 | 10 | + |
| 38 | Concepts in mathematics that I found difficult before are clearer when presented through CAI. | 95 | 0 | 5 | + |
| 39 | The colour, graphics and animation in CAI has helped me understand mathematical concepts better. | 100 | 0 | 0 | + |
| 40 | The navigation capabilities provided in the CAI software is clear and logical that I know exactly where I am in the CAI-mediated mathematics lessons. | 95 | 5 | 0 | + |
| 41 | The colour, graphics and animation in CAI is distracting for me making CAI less effective as a learning tool. | 0 | 5 | 95 | - |
| 42 | Even if I had a computer I would still prefer books and face-to-face tutorials to study an mathematics course including mathematics 2. | 20 | 10 | 70 | - |
| | Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree | | | | |

Although students had had four weeks of exposure to computers it was felt that this short period was inadequate for them to form reliable attitudes towards computers. Ten items, about 30 percent of all items, still showed a "NS" rate of 20 percent or more compared to 40 percent in CSQ1. In contrast to CSQ1 in which 25 percent of the items had a "NS" rate of 30 percent or more only 5 percent of the items in the CSQ2 questionnaire had a "NS" rate of 30 percent or more. There was a lack of a clear-cut tendency in response patterns in only about four or five (about 10%) of the items compared to about a third of the items in CSQ1. There clearly was a lessening in CSQ2 of the uncertainty that existed in CSQ1.

Although there was still evidence of the uncertainty and inconsistency in student response patterns that was noted in CSQ1, this was to a lesser degree in CSQ2 as portrayed by the indicators discussed above. It appears that exposure to the computer-based mode of instruction, although rather brief, resulted in the reduction of levels of uncertainty and inconsistency in student response patterns. The conclusion therefore that the student responses on the CSQ1 Likert scale were unreliable because of limited exposure to computers appears to be a valid one. This further justifies therefore the decision not to perform any other statistical analysis on the results from both CSQ1 and CSQ2 in the pilot study.

The 36 items in the CSQ2 Likert scale were also subjected to Cronbach's Alpha reliability test, as reported in appendix P11. The overall measure of internal consistency for the 36 items of the CSQ2 was 0.88, which falls well above the critical value of 0.7. There is therefore very good support for the internal consistency and hence the reliability of the overall scale as a measure of a construct. On the basis of this level of internal consistency, summary statistics as reported in appendix P12 were produced as a further indication of the tendency of student attitudes to computers. The summary statistics show that the students have positive attitudes to computers as indicated by their median scores. All items except Items 14, 15 and 27 had medians of 4.0 or more in a scale from 1 to 5 implying a positive attitude to computers. Of course, as in CSQ1, the information the summary statistics provides has to be understood within the confines of the reservations expressed in regard to the students' lack of adequate exposure to computers and what that implies.

### 4.7.4 Instrument 4 - Posttest

A copy of this test appears in appendix P13. Due to the compressed (4 weeks) time frame for the pilot study and the abrupt ending, it was not feasible to implement this test according to the pretest-posttest, nonequivalent control group design

(Wiersma, 2000: p 132) as intended. The plan was to give this test as a pretest to students in both groups before any tutorials of any form in the course were provided and as a posttest at the end of the tutorials to compare performances in the test prior to instructions and performances post-instruction. This plan however was abandoned for the pilot study because of the late installation of the CAI software as discussed earlier. Instead a Posttest-Only, nonequivalent control group design (Wiersma, 2000: p 129) was implemented in the pilot study.

All students were taught for the first 8 weeks via the usual combination of limited FTF tutorials (2 hours per week) and self-study while waiting for the CAI software to be installed. The performance test was therefore given entirely as a single test at the end of the period of instruction (posttest) and the results were used mainly to check the test parameters of difficulty, facility and discrimination indices of the questions in the performance test (see appendix P14).

Some hypothesis testing was also done in relation to the results obtained by students in this test and the Final Examination comparing the difference in performances between the CAI group and the TM group. Table 4.13a and b report the comparative performances of the CAI and the TM groups under the Mann Whitney U Test. This test and the rationale behind its use, as well as the hypotheses it was testing are discussed in detail in section 4.11.1.

Following the analysis of the pilot study data a number of test items were either replaced or modified on the basis of their discrimination and facility indices (appendix P14) in preparation for the main study. These changes are described in chapter 5. Ideally the modified form of the performance test should have been piloted again before the main study but time constraints did not allow that to be done.

## 4.8 General Reflections on the MAQ, CSQ1 and CSQ2 in the Pilot Study

### 4.8.1 MAQ

The analysis of the responses to the MAQ showed that in general the sample population had fairly positive attitudes to mathematics. That there was no particular reason stemming from the analysis of the data to suspect that as a group the sample population were anti-mathematics and that they were doing the course entirely as a necessary evil.

Problems were identified with various items in the MAQ, which needed to be addressed before the main study. Changes made to the structure and design of the MAQ in preparation for the main study following the pilot study are discussed in chapter 5.

Other areas of concern that the MAQ did not adequately address, which were noted in analysing the responses to the MAQ in the pilot study, were the difficulty of pinpointing sources of misunderstanding in the items in the questionnaire and why the students responded the way they did. These areas of concern were crucial because they would have affected the way students responded.

It was not possible to work out from the analysis how the students understood each item in the questionnaire and which items were misunderstood and how. The student sample as a whole, as well as each student individually, could very well have been responding to a different item to what the researcher thought they were responding to. A personal, face-to-face interview with a sub-sample of students may have clarified the situation somewhat. However no personal, face-to-face interviews were conducted either in the pilot study or the main study.

It was also found just as difficult to determine whether the students were responding in the way they did in order to conform to some view of political correctness they had and were aiming to 'please' the researcher or because that was their genuine, independently held, personal opinion. This point applies to all three-attitude questionnaires. This difficulty is under-scored by the impression that many have that Papua New Guinea students generally do not like being seen as being out of step with what they think is the politically correct and acceptable attitude to hold, even if they disagree with it. Hence the responses may well have been meant for the researcher rather than a reflection of what the students actually believed.

To address the foregoing concerns adequately would have required more elaborate measures, which would have increased the complexity and the duration of the study.

In summary, the students' views were far from unanimous, although overall the majority of students tended to favour a positive view of mathematics in each of the forty-five items. The presence of complicating variables that could not be explained adequately makes the interpretation of the resulting data in the MAQ in the pilot study complicated.

It would have been ideal to pilot the questionnaire again after the modifications before the main study but this was not possible due to time limits.

### 4.8.2 CSQ1 and CSQ2

The original idea in having a pre (CSQ1)/post (CSQ2) arrangement in the computer attitudes questionnaire was to compare students' responses in CSQ1 to their responses in CSQ2. Hence the presence of common items in the two questionnaires to facilitate the comparison. This idea was abandoned though when 65 % of the students who responded to item 3 in CSQ1 (*I have used a computer before*) indicated a lack of adequate experience in the use of computers. This threw a lot of doubt on the reliability of the students' responses in CSQ1 in particular. Hence it was decided that in the analysis of the data for the main study for CSQ1 and CSQ2, the main data presentation would consist entirely of frequency summaries of responses in a form similar to that in the pilot study (see tables 4.7 and 4.8). The frequency summary table basically shows patterns and tendencies of student responses in terms of response frequencies of scale points.

Changes in structure and design made to both the CSQ1 and CSQ2 in preparation for the main study following the pilot study are described in chapter 5.

### 4.8.3 Factor Analysis of the MAQ, CSQ1 and CSQ2 Results in the Pilot Study

It was the intention of the researcher to conduct factor analyses on the MAQ, CSQ1 and CSQ2 questionnaire data in the pilot study but as discussed in the preceding sections, only descriptive results (frequency summary statistics) were produced for all three questionnaires. The reasons for this have already been noted in sections 4.7.1 - 4.7.3.

Both CSQ1 and CSQ2 were rendered unsuitable for factor analysis by the students' lack of experience with computers as indicated in Item 3 in CSQ1. For the MAQ an attempt at factor analysis using the statistics package SPSS version 9.0 indicated that the data in the pilot study was inadequate for the purposes of a factor analysis. This was shown by an MSA (Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (MSA)) of less than 0.6 (see table 4.9) even though the Bartlett's Test of Sphericity shows that there were significant correlations in response tendencies between items in the questionnaire.

**Table 4.9: KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | *.430* |
| Bartlett's Test of Sphericity | Approx. Chi-Square | *1524.179* |
| | df | *990* |
| | Sig. | *.000* |

Literature (e.g. Francis (1999: p. 147)) suggests that in order for the data from a questionnaire to meet minimum levels of adequacy for factor analysis, the MSA must be greater than 0.6. The MSA for the MAQ in the pilot study was only 0.43 as shown in table 4.9 above, which obviously was less than adequate for the purpose of factor analysis. It was therefore decided not to conduct a factor analysis for the MAQ as well in the pilot study. But the questionnaires were modified on the basis of the pilot study data with the aim of improving them to meet the minimum levels of adequacy for factor analysis in the main study.

The implications for the validity of the MAQ questionnaire data posed by the low MSA and the subsequent decision not to conduct factor analysis on the questionnaire in the pilot study are discussed in section 4.10.

## 4.9 Reliability Concerns for the Questionnaires and tests data

Reliability is a measure of the internal consistency of a set of scale items. There are several different numerical methods of quantifying the statistical measure of reliability for a scale. For this study the Cronbach's Alpha Coefficient was chosen because it is the most commonly used measure of reliability and is also the most suitable measure where the data is obtained from just one administration of a test or questionnaire (Wiersma, 2000). Cronbach's Alpha is based on the average correlation of items within a test if the items are standardised, and if not standardised, it is based on the average covariance among the items (Coakes and

Steed (1999)). Cronbach's Alpha coefficient is therefore a measure of how well different items correlate with each other in their measurement of the same quality or dimension (Fink and Kosecoff (1998: p. 34)).

### 4.9.1 Reliability Concerns for the Likert Scales of the MAQ, CSQ1 and CSQ2 in the Pilot Study

Francis (1999) suggests that a Cronbach's alpha level of 0.7 would be acceptable for a scale such as that for the MAQ, CSQ1 and CSQ2.

In each of the three questionnaires, the one (there were no sub-tests in all three for the pilot study) scale consists of all the items in the questionnaire. Oppenheim (1992: p 147) states that:

> Sets of questions are more reliable than single opinion items; they give more consistent results, mainly because vagaries of question wording will probably apply only to particular items, and thus any bias may cancel out, whereas the underlying attitude will be common to all the items in a set or scale.

The attitude scales for the MAQ, CSQ1 and CSQ2 were all multi-item scales and it was therefore expected that biases due to vagaries of wording would have been taken care of sufficiently by this fact. Table 4.10 below tabulates the Cronbach's Alpha reliability coefficients for the overall scale for the MAQ, CSQ1 and CSQ2. In each case it can be seen that the Alpha level is well above the required minimum level of 0.7 that was set for the scale to be considered internally consistent hence reliable. It therefore follows that the overall scales for each of the three questionnaires was accepted as internally consistent and satisfied the set minimum levels of reliability.

*Table 4.10 Cronbach's Alpha Levels for the MAQ, CSQ1 and CSQ2 Likert Scales*

| Questionnaire | Alpha Level |
|---|---|
| MAQ | 0.86 |
| CSQ1 | 0.79 |
| CSQ2 | 0.88 |

### 4.9.2 Reliability Concerns for the Posttest in the Pilot Study

The reliability of the posttest could not be established on the basis of an inter-item reliability coefficient as in the questionnaires because individual student scores in each question in the posttest were not recorded. The test answer scripts in the pilot study were too bulky and expensive to airfreight to Monash University from UPNG at the end of the field study and were therefore left behind at UPNG. The information therefore could not be recorded retrospectively. This oversight can be explained as the direct result of the disadvantage of fieldwork that is conducted away from the "home" Institution and supervisors, resulting in a lack of regular advisory consultation.

However, while the reliability of this instrument in the pilot study cannot be argued on the basis of an inter-item reliability coefficient, it can be argued on the basis of its content validity as established in the next section (4.10). Various writers (e.g. Fink and Kosecoff (1998)) note that while a reliable test is not always valid, a valid test is always reliable. On this basis therefore a case can be made that the posttest in the pilot study was reliable by reason of its established validity within the context of the course objectives of mathematics 2.

In the main study (see chapter 6), reliability for the performance test was established using the test-retest method because the same test was given to the same group of students first as the pretest and then as the posttest. Using this method the two sets of scores were correlated using the Spearman rank correlation coefficient which was significant at the 0.01 significance level (see table 6.11 in chapter 6 – main study results). This was basically the same test that was used in the pilot study with only a few changes. Therefore it can also be argued retrospectively from the main study that the performance test (posttest) in the pilot study had internal consistency and was therefore reliable.

## 4.10 Validity Concerns for the Questionnaires and Tests Data in the Pilot Study

Validity describes the extent to which an instrument such as a survey questionnaire measures what it is supposed to measure. There is some consensus in literature of the existence of three main forms of validity: content, criterion and construct (Wiersma, 2000: p. 299). However, a more contemporary view sees validity as a unitary concept and that there are only different types of evidence of validity, rather than distinct types of validity (Ibid. pp. 300-301). This difference appears to be a conceptual one rather than a technical one as the procedures for establishing validity are essentially the same for both views. In this study it was felt that the unitary view provided a more appropriate backdrop to the arguments for the validity of the instruments.

The concept of statistical validity for a questionnaire or a test is a more difficult concept to establish than reliability but is nonetheless a very important quality. The following section presents arguments for the validity of the MAQ, CSQ1 and CSQ2 scales.

### 4.10.1 Validity Concerns for the Likert Scales of the MAQ, CSQ1 and CSQ2 – Pilot Study

The two ways in which the validity of a scale can be established are:

1. A logical analysis of the content of an educational trait or construct or characteristic
2. An empirical analysis.

#### 4.10.1.1 Instrument 1 - MAQ

Since the MAQ scale was an original scale specifically developed for this study with items from various sources, including original items put together, only the first of the two ways applied. In this regard the validity of the MAQ could only be argued on the basis of the representativeness of the items that supported the underlying constructs in the questionnaire data in the pilot study. This was going to be done using the concepts of convergent and discriminant validity which are sub-categories of construct validity (Trochim, 2000). Convergent validity postulates that measures or items, which are related, should show high inter-correlations. Discriminant validity on the other hand postulates that measures or items, which are not related, should show low inter-correlations.

The MAQ scale in the pilot study was not subjected to factor analysis as it was in the main study because of a less than adequate MSA as discussed in section 4.8.3. There were therefore no sub-tests established in the analysis of the MAQ scale in the pilot study. Hence the validity concerns for the MAQ involves only the one scale, ie the overall scale consisting of the 45 items. This made it impossible to subject the data to convergent and discriminant validity analysis as intended.

The data from the MAQ in the pilot study was therefore used entirely as a means towards improving the instrument for the main study. Although validity other than face validity could not be established for the MAQ in the pilot study there was evidence of significant inter-item correlations, as suggested by the significance of Bartlett's Test for Sphericity (see table 4.9). The significance of Bartlett's Test for Sphericity suggested that with further development, the MAQ questionnaire data might be made to reach an acceptable level of MSA and thus subjected to factor analysis. This would then make it possible to investigate its validity through the convergent and discriminant method of construct validity in the main study.

#### 4.10.1.2 Instruments 2 and 3 - CSQ1 and CSQ2

Although reliability was established for CSQ1 and CSQ2 (table 4.10), i.e. they were at least internally consistent in measuring some construct, validity proved to be a very difficult property to establish for the two questionnaires. The arguments for the validity of CSQ1 and CSQ2 were dogged with the same problems as those for the MAQ i.e. very low MSA, rendering them somewhat unsuitable for factor analysis. In addition there were the questions on the validity of both CSQ1 and CSQ2 stemming from the indication by 65 percent of the CAI student sample of inadequate experience with the use of computers. As discussed in a previous section the observed response patterns in the frequency summary tables suggested that the instruments needed to be improved. The instruments were therefore appropriately modified based on other statistical indicators from the data collected in the pilot study with the hope that the scope for the establishment of validity for the instruments would be enhanced in the main study (see chapter 6).

### 4.10.2 Validity Concerns for the Posttest - Instrument 4

The validity of the posttest was established on the basis of a content analysis of mathematics 2 by comparing the results from the posttest with the results from the Final Examination at the end of semester 2, 1999 (table 4.2). While the researcher wrote the posttest, the IDCE mathematics coordinator independently wrote the final examination. The correlation between the two tests was significant at the 0.01 significance level, suggesting that the two tests were testing in the same domain of objectives. That the posttest would test in the same domain of objectives as the final examination was obviously consistent with the essential purpose of the posttest, and thus indicates face validity in the posttest.

The application of Bloom's taxonomy to draw up a grid of content objectives as a means of validating the instruments was considered and then abandoned when it was realised that the content objectives were concentrated around the knowledge, comprehension and application areas of the taxonomy.

The validity of the posttest scale was therefore accepted on the basis of the strong correlation between the posttest and the final examination.

## 4.11 Statistical Procedures used in the Pilot Study

While most of the analysis of the data from the four instruments consisted of descriptive results such as frequency summary distribution tables, the two other statistical analyses performed on the data were correlational analyses and the non-parametric Mann Whitney U test.

A correlation analysis was carried out to ascertain whether or not there was any relationship between the students' attitudes towards mathematics and their performance in the posttest (see table 4.12). There was also a correlation analysis to determine whether or not there was a significant association between performance on the posttest (in the pilot study) and performance in the final examination (see table 4.2). This was done in order to determine whether the two tests were testing within the perimeter of the same set of objectives or in different sets of objectives. A weak correlation would have cast serious doubts on the validity of the posttest as an instrument for comparing performance outcomes between the CAI group and the TM group within the context of the mathematics 2 syllabus.

The Mann Whitney U test was performed on the MAQ data (see section 4.11.2 below) to determine whether the CAI students had more positive attitudes to mathematics than TM students or vice versa. This was intended to determine whether the convenience samples sampling method, which was employed in creating all samples in this study resulted in statistically significant bias in sampling. The demonstration of statistically significant bias in the data would have invalidated the attempts at comparing the results derived from the samples because it would have shown that students were self-selecting themselves into the two samples according to some pre-existing unknown preference factor. A full discussion of the application of the Mann Whitney U test together with the hypotheses that the test was applied to in the pilot study is provided in section 4.11.1 below.

The Mann Whitney U test was also applied to the posttest and the final examination results to compare relative performances between the CAI and the TM groups to determine whether there was a significant difference in performances between the two instructional mode groups in the two tests (see section 4.11.3).

### 4.11.1 The Mann Whitney U Test and the Spearman Rank Correlation Coefficient

The use of the Mann Whitney U test and the Spearman Rank Correlation Coefficient for this research relates back to the arguments for the use of the median instead of the mean discussed earlier under section 4.7.1 in conjunction with the results for Instrument 1. The researcher felt that the data from the present study did not meet the strict requirements for the use of the parametric t-test and the Pearson Moment Correlation coefficient (Siegel and Castellan (1988).

The Spearman Rank Correlation Coefficient is the non-parametric equivalent to the parametric Pearson Moment Correlation coefficient and is based on the mean rank of scores rather than the mean of scores. Given the ordinal nature of the data in the present study the Spearman Rank Correlation coefficient was considered more appropriate in the correlation analysis of the data.

The Mann Whitney U, tests whether or not two samples come from populations having the same distribution and is a non-parametric equivalent to the Independent-Samples T-test for independent groups as noted for instance by Francis

(1999: p. 161) and Coakes and Steed (1999: p. 202). In the present study the Mann Whitney U test is chosen ahead of the parametric Independent-Samples T-test because it can be used with ordinal data such as the data derived from the application of the MAQ and the Posttest.

Parametric tests and measurements assume certain statistical preconditions such as random selection of samples as well as ratio level data and the consequential shape of the underlying distributions. The Mann Whitney U does not make any assumptions about the shape of the underlying distributions (Francis, 1999: p. 161). Regardless, Siegel and Castellan (1988: pp 128-137) state that this is one of the most powerful of the non-parametric tests. It is a very useful alternative to the Independent-Samples T-test for Independent groups when the data is weaker than interval or ratio level and there is good reason to avoid the assumptions inherent in the Independent-Samples T-test.

### 4.11.2 A Comparison of the CAI and TM Students' Overall Attitude to Mathematics Scale

The Mann Whitney U test was applied to the MAQ data to test for differences in attitude to mathematics between the CAI sample and the TM sample. As stated in section 4.3.3.1, the detection of a difference in attitudes would suggest the existence of significant bias in sampling, ie the students were self-selecting themselves into one of the two instruction mode groups according to some unknown pre-existing bias factor.

The Spearman Rank Correlation was applied to identify any significant association that might exist between the students' attitudes to mathematics and their performance in the Posttest. This was to determine the extent to which the students' attitude to mathematics affected their performance in the Posttest.

As discussed earlier there were no sub-tests for the MAQ in the pilot study because the pilot study data could not be subjected to factor analysis (see section 4.8.3) hence the only scale that was subjected to the Mann Whitney U test was the overall attitude to mathematics scale.

The following were therefore the questions from which the hypotheses in the pilot study were generated.

1. Is there a significant difference in attitude to mathematics between the students in the CAI sample and the students in the TM sample?
2. Is there an association between the students' attitudes to mathematics and their performance in the posttest?

Table 4.11b below tabulates the results of the Mann Whitney U test-testing hypothesis 1, which compares the attitudes of the CAI and TM students to mathematics.

$H_{o1}$: There is no difference in attitude to mathematics in general between the CAI Group and the TM Group.

***Table 4.11: Comparative view of Mathematics between CAI and TM students***

**Table 4.11a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Overall view of Mathematics | CAI | 27 | 33.91 | 915.50 |
| | TM | 36 | 30.57 | 1100.50 |
| | Total | 63 | | |

**Table 4.11b: Test Statistics**

| | Overall view of Mathematics |
|---|---|
| Mann-Whitney U | 434.500 |
| Wilcoxon W | 1100.500 |
| Z | -.716 |
| Asymp. Sig. (2-tailed) | .474 |

a. Grouping Variable: Class Group

It is clear from table 4.11b that $H_{o1}$ is retained, ie there is no significant difference in attitudes to mathematics between the CAI students and the TM students based on the mean rank view of each student. This outcome suggests that regardless of the convenience samples sampling method employed in creating the CAI and TM samples, the data were largely free of sampling bias.

Table 4.12 below tabulates the results of a non-parametric (Spearman's rho) correlation analysis investigating whether there was a significant association between high positive attitude to mathematics and performance in the Posttest.

$H_{o\,2}$: There is no correlation between the students' general attitudes to mathematics and their performance in the mathematics posttest.

**Table 4.12: Correlations**

| | | | Posttest Scores |
|---|---|---|---|
| Spearman's rho | Overall view of Mathematics | Correlation Coefficient | .543** |
| | | Sig. (2-tailed) | .005 |
| | | N | 25 |

**. Correlation is significant at the .01 level (2-tailed).

It is clear from table 4.12 that $H_{o\,2}$ is rejected, ie there is a significant association between students' attitudes to mathematics and their performance in the Posttest.

### 4.11.3 A Comparison of the CAI and TM Students' Performance in the Posttest and the Final Examination

The main focus of the research in the pilot study was to detect differences in the performances of mathematics 2 students in the Posttest and the Final Examination following a period of instruction by two different methods of instruction. There was a time lapse of a period of about seven weeks between the sitting of the posttest and the sitting of the final examination.

The two questions below were generated to compare the performance of students in the posttest with their performance in the final examination in mathematics 2.

1. Is there a significant difference in performance between the CAI Group and the TM group in the Posttest?
2. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination?

Table 4.13b below tabulates the results of the Mann Whitney U test-testing null hypotheses 1 and 2 comparing the performances of the CAI and TM students in the Posttest and the Final Examination.

$H_{o1}$ : There is no difference in performance on the Posttest between the CAI Group and the TM Group.

$H_{o2}$ : There is no difference in performance on the Final Examination between the CAI Group and the TM Group.

***Table 4.13: Performance Differences between CAI and TM Students in the Posttest and Final examination***

**Table 4.13a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Posttest Scores | CAI | 18 | 16.92 | 304.50 |
| | TM | 15 | 17.10 | 256.50 |
| | Total | 33 | | |
| M2FEX | CAI | 18 | 17.78 | 320.00 |
| | TM | 15 | 16.07 | 241.00 |
| | Total | 33 | | |

**Table 4.13b: Test Statistics[b]**

| | Posttest Scores | M2FEX |
|---|---|---|
| Mann-Whitney U | 133.500 | 121.000 |
| Wilcoxon W | 304.500 | 241.000 |
| Z | -.054 | -.506 |
| Asymp. Sig. (2-tailed) | .957 | .613 |
| Exact Sig. [2*(1-tailed Sig.)] | .957[a] | .630[a] |

a. Not corrected for ties.

b. Grouping Variable: Class Group

It is obvious from table 4.13b that both hypotheses are retained, ie there is no significant difference in performance between the CAI students and the TM students in both the Posttest and the Final Examination based on the mean rank of the students in the two samples. This outcome suggests that the two methods had similar effect on students. A logical conclusion that follows this outcome therefore is that both methods are equally good. This is a rather important conclusion because the aim of this study was to investigate the efficacy of a CAI – mediated learning environment that can coexist with the more familiar face-to-face and text-based instructional modes. CAI being more attuned to individualised learning is more conducive to a distance education setting such as that which exists in IDCE where a properly qualified mathematics teacher is not always readily available.

Two compounding considerations, which cast some doubt on the level of confidence that can be placed on the results from the Mann Whitney U and the Spearman Rank Correlation analyses, were the rather small sample sizes and the rather short duration of the observed tutorial period (4 weeks). Only those students who sat the posttest were included in the comparison of the Mann Whitney U test. This was a fairly small sample as is obvious from table 4.13a.

## 4.12 Summary

The Methodology used in the pilot study, as well as the pilot study results, were presented in this chapter. Four instruments were used for the data collection for this study these were the MAQ, CSQ1, CSQ2 and the Posttest. Due to problems encountered in the pilot study there was no pretest.

The study was conducted in the mathematics 2-course domain facilitated by a Computer-assisted Instruction (CAI) software named Lebo 1.0, which was specifically developed by the researcher for the present study.

The pilot study ran into some teething problems at the start, compounded at the end by a student strike, which affected its implementation resulting in an abbreviated pilot project of four weeks duration. Although the three questionnaires, MAQ, CSQ1 and CSQ2, were found to be internally consistent for the overall scale for some construct, validity was found to be difficult to establish. They were therefore modified as required by the available data with the hope that they would be better instruments in the main study.

It was found from the Posttest and the final examination in mathematics 2 that there was no significant difference in performance between the CAI students and the TM students inviting the conclusion that the two methods of instructions were equally effective. There were some causes for doubt about these conclusions though because of the rather small sizes of the samples and short duration of the instructional period.

It was also found that there is a significant link between attitudes to mathematics and performance in the posttest, implying that students with more positive attitudes to mathematics perform better than students with less positive attitudes to mathematics.

A number of major problems were encountered in the conduct of the pilot study as described in this chapter but regardless of these problems the pilot study was concluded successfully under the circumstances.

The next chapter (Chapter 5) provides a descriptive account of the main study carried out following the pilot study including descriptions of the changes made to the research instruments and the CAI software in preparation for the main study.

# Chapter 5: Main Study

## 5.1 Introduction

This chapter provides a descriptive account of how the main study was conducted. The account includes:

- A description of the general procedures and methodology used in the conduct of the main study
- A discussion of the Sampling and Research Population Parameters used in the main study
- Brief descriptions of the five instruments used in the main study.
- A brief description of the computer software version used in facilitating the main study.
- Data collection procedures

In general most procedural steps implemented in the pilot study were replicated in the main study. The Instruments were modified to some extent following the pilot study but remained largely the same in many respects. The descriptions of the five instruments used in the main study are therefore necessarily brief because they have already been described in detail in Chapter 4.The changes made to the instruments as a result of the pilot study are described in section 5.3.2 of the present chapter.

## 5.2 Main Study

The Main Study was conducted in the first semester of 2000 at the Main Campus of UPNG. This was the semester following the semester in which the pilot study was conducted. The first semester at UPNG extends from the beginning of February to the beginning of June. As discussed in chapter 4 a decision was made following the pilot study to limit the actual research-related instruction time to just the first seven weeks of the semester. Therefore the main study was conducted from early February to early April of 2000 for seven weeks and was terminated by the posttest, which also doubled as the mid-semester test. There were no problems associated with software installation or the scheduling of classes as in the pilot study and consequently both CAI and TM classes commenced as scheduled and on time. The only major problem encountered during the main study was intermittent power supply interruptions, which were experienced throughout the National Capital District (NCD) at that time. There was some loss of time due to these interruptions but on the whole the tutorial sessions went well and according to plan.

### 5.2.1 Location of Study and Physical Facilities used in the Research

Just as in the pilot study the main study was conducted exclusively at the main centre of IDCE on the Main Campus of UPNG. The same logistics conditions as applied in the pilot study were responsible for the geographical restriction of the study to the Main Campus of UPNG only. Adequate computer resources were available only at the Main Campus of UPNG.

The CAI tutorial sessions were conducted in the same two CSU (Computer Services Unit) laboratories used in the pilot study. The main study followed the pilot study in the semester immediately following and consequently there were virtually no changes at all in the physical setup of the two laboratories. The two laboratories consisted of 36 IBM compatible networked PCs with a Windows NT operating system environment.

### 5.2.2 Tutorial Sessions conducted in the Main Study

Four CAI tutorial sessions were scheduled each week for the seven weeks of CAI tutorials to allow the CAI students options with their individual timetables. Consequently each tutorial session was conducted on a separate day at various times of the day to cater for the needs and preferences of individual students as well as for the various student groups. For instance there was an after-hours tutorial session for students who were employed and could only make it to the tutorials after working hours. Again as in the pilot study, each student was allowed attendance at only one CAI tutorial session per week in keeping with the usual level of FTF sessions normally available to each student in the course. An attendance roll was kept for the

CAI students in every session. This facilitated the decision made following the pilot study that the CAI students' performance in the posttest would be analysed according to the number of tutorials attended.

There were also a number of tutorial sessions conducted for the TM group but these tutorials were supervised directly by the Mathematics Coordinator of IDCE and not the researcher. The researcher was kept informed of the progress of the TM tutorial sessions at all times.

TM students were also allowed attendance at only one FTF tutorial session per week, as is the usual practice. Again as in the pilot study it wasn't considered necessary to keep an attendance record for the TM group.

Each tutorial session for both groups was 2 hours in length with an estimated effective contact time of just over an hour, the same as in the pilot study.

The researcher was assisted in conducting the CAI tutorials by one other tutor who acted the role of support staff. This role included being in charge of the tutorial session on the few brief occasions when the researcher had to be absent from the laboratory for various reasons. The tutor thus used was competent in computer usage and was familiar with the software.

## 5.3 Sampling Parameters of the Research Population

The research population for the main study was the student cohort of semester 1, 2000 enrolled in the adult matriculation course mathematics 2. The research population is a part of the larger adult matriculation population of IDCE and is largely equivalent to that for semester 2, 1999 sampled in the pilot study, as shown in table 5.1. A typical student enrolled in the mathematics 2 course was described in the pilot study in table 4.3 in chapter 4 and is compared in table 5.1 below with the student information data collected in the main study.

### 5.3.1 Sample Population

The sample population on which the main study was conducted consisted of adult matriculation students enrolled in the first semester of 2000 in mathematics 2 (27.023) at the Main Campus centre only. The population demographics charts are reported in appendix M1. Table 5.1 below provides a summary of the population demographics charts and provides a comparison with those in the pilot study sample. From the table it is clear that there is very little difference in sample population characteristics over the two semesters in which the fieldwork was conducted.

*Table 5.1: A Comparison of Sample Population Characteristics between the Pilot Study and the Main Study.*

| Pilot Study (semester 2, 1999 cohort) | Main Study (semester 1, 2000 cohort) |
|---|---|
| • 75% of the sample was in the 18-24 years age group | • 71% of the sample was in the 18-24 years age group |
| • 81% of the sample was male | • 74% of the sample was male |
| • 81% of the sample had enrolled in the Adult Matriculation program after completing grade 10 only | • 81% of the sample had enrolled in the Adult Matriculation program after completing grade 10 only |
| • About 32% of the sample had attended some form of tertiary education | • About 36% of the sample had attended some form of tertiary education |
| • About 30% of the sample were repeating the course mathematics 2 | • About 33% of the sample were repeating the course mathematics 2 |
| • At least 30% of the sample listed a trade or occupation. | • At least 31% of the sample listed a trade or occupation. |
| • About 32% of the sample were employed | • About 29% of the sample were employed |

Table 5.1 above, which compares the sample population characteristics in the pilot study with those in the main study, shows that the different sampling methods used produced similar results i.e there was very little difference statistically between the sample populations of the pilot study and the main study. The significance of this conclusion derives from the fact that whereas convenience sampling was employed in the pilot study, in the main study comprehensive sampling was employed in creating the main sample population.

As in the pilot study, much the same general points can be made about the sample population in the main study. Between 70 to 80 percent of the students were young adults in the 18-24 year age group, not too long out of school in both the pilot and the main studies. Just over 80 percent of the students had enrolled in the adult matriculation program after completing grade 10 only but with at least 95 percent having had, at least a grade 10 level of general education. The population was over

70 percent male and about 30 percent had also had some form of tertiary education. At least 30 percent of the students, in both the pilot study and the main study sample populations, were repeating the course from a previous semester.

These population statistics suggest that the intake into the matriculation program, and by extension into mathematics 2, remains fairly uniform from semester to semester.

### 5.3.2 Sampling Methods employed other than Random Sampling

As noted in section 5.2.1 the reasons for the selection of UPNG Main Campus as the site for the main study were the same as those for the pilot study and are described in chapter 4. The site selection was based on the researcher's personal knowledge of the situation in Papua New Guinea regarding the availability of computer resources and could therefore be regarded as purposeful sampling.

Comprehensive sampling was the sampling method employed in selecting students for the main sample population in that all students enrolling in mathematics 2 in semester 1 of 2000 at the Main Campus of UPNG were included in the study. A total of 131 students enrolled for the course at the beginning of the semester on the Main Campus of UPNG, but only 99 students completed the personal information sheet and the MAQ questionnaire. This equated to a return rate of some 76 percent.

A course dropout rate of 25 to 35 percent is not unusual in the IDCE mathematics courses. Therefore the 99 students represent the estimated percentage that would normally have completed the course. In fact as it turned out only 86 students or 66 percent of the students who enrolled initially eventually completed the course in semester one of 2000, as shown by those who sat for the final examination some 14 weeks later (see chapter 6, tables 6.20a - 6.25a}. This translates to a dropout rate of some 34 percent. Students who register for courses with IDCE are deemed to have completed the course once they sit the final examination.

A number of students who enrolled for mathematics 2 in semester 2, 2000 dropped out of the course before the posttest (mid-semester) and a few more after the posttest but before the final examination. The discontinuations from the course occurred right throughout the semester. Therefore the number of students enrolled in the course, the number of students who sat the posttest 7 weeks into the semester and the number of students who sat the final examination in mathematics 2 were all different. The tables displaying the results of the tests of hypotheses in chapter 6, section 6.8 provide indications of the relevant sample sizes in the various analyses.

### 5.3.3 Random Sampling

The only attempt made at random sampling was in the creation of the two treatment groups. This was not very successful though because of the population dynamics of the distance education, adult matriculation population, which is very fluid.

One of the basic tenets of the distance education program at UPNG is the total freedom accorded to students to choose either to attend or not to attend set tutorial sessions. It follows therefore that students could not be 'forced' to continue with tutorials of any description if they chose not to be involved in tutorials. They were allowed to discontinue attending tutorial sessions without penalties or change to another more convenient tutorial session in total freedom. This meant of course that the list of randomly selected students to either of the two treatment groups did not remain entirely intact throughout the period of the study.

Moreover the freedom of the students to drop out of the study in total freedom is required by the SCERH (Ethics) regulations of Monash University for subject participation in a research study. There was a core of randomly selected students who did remain with the respective groups they were randomly assigned to, throughout the period of observed tutorial sessions.

In general the CAI group was affected by students dropping out and not seeing the program to the end of the seven weeks of instruction. In contrast the TM group was affected by the addition of students to the group as a result of dropping out of the CAI group. The movement of students was generally from CAI to TM. There were a few who went the other way in the first two weeks of the tutorial sessions but the researcher did not allow the movements from TM to CAI to continue after the second week of the tutorial sessions.

### 5.3.4 Research Groups

**Group 1: The CAI Sample**

CAI students had to attend CAI tutorials to be treated as CAI instructed students in the data analysis. In the context of the main study CAI students who missed tutorial sessions were treated as TM students for the particular sessions they missed. No such requirement was imposed on the TM group because the TM mode of instruction included all modes other than CAI.

At the end of the seven weeks of research-related instructions the attendance roll showed varying levels of attendance at tutorials. The test of hypotheses on students' performances in the posttest (section 6.8.2) and the final examination (section 6.8.4) were based on the attendance record of the CAI students.

The various levels of attendance at CAI tutorials by the CAI group were depicted as "situations" in the tests of hypotheses in section 6.8.2 for the posttest and section 6.8.4 for the final examination. There were six situations in total with "situation 1" representing the case of at least one attendance at CAI tutorials and so on with "situation 6" representing attendance at six or seven CAI tutorial sessions. There were only seven tutorial sessions in total. The information on the relevant sample sizes is provided in table 6.12a for the pretest, tables 6.13a - 6.18a for the posttest and tables 6.20a - 6.25a for the final examination.

Another factor aside from but related to population dynamics which played a part in deciding the sample sizes of the various CAI samples in the analysis was completion of the posttest. Only those CAI students who sat the posttest at the end were included in the CAI samples for data analysis for obvious reasons. The combination of these factors resulted in the sample sizes being rather small.

**TM Sample**

The rest of the students not included in the CAI samples in the analysis were automatically treated as TM students and analysed accordingly. The number of TM students also varied from situation to situation in inverse proportion to the variation in the CAI student samples. As noted above non-attendance at CAI tutorials automatically classified a student as a TM student for that particular tutorial session.

With time and additional resources it would have been more informative to split the TM group into more than one group instead of the one as in the present study. Two possible samples would have been TM students who attended FTF tutorials and the TM students who did not attend FTF tutorials.

## 5.4 Research Domain, Computer Software and Instruments used in the Main Study

### 5.4.1 Research Domain and Computer Software

**Research Domain**

As it was in the pilot study, the domain that was selected for this study was the adult matriculation (AM) course, mathematics 2 (27.023). No changes were made to this course over the two semesters under scrutiny, therefore no further description of the course is deemed necessary. The reader is referred to the full description of the course provided in section 4.3.1.

**Computer Software**

The computer software used in the main study was Lebo 1.5 – An Interactive Mathematics 2 Project, which was an upgrade version of Lebo 1.0 – An Interactive Mathematics 2 Project used in the pilot study. Lebo 1.5 was similar to Lebo 1.0 in almost every respect including its organisational structure. The only differences were that Lebo 1.5 had additional functionality in terms of more examples and the inclusion of exercises in the software itself. In the pilot version (Lebo 1.0) the exercises remained in the course booklets and were only referred to, whereas in Lebo 1.5 many of the exercises were actually built into the software itself and the students had to complete them on-screen.

In the light of experiences from the pilot study the navigation buttons and instructions were also more clearly labelled, more strategically positioned and generally more aesthetically enhanced in Lebo 1.5. The navigational routes from page to page and concept to concept possible in the software were also improved to enhance the user-friendliness of the software in Lebo 1.5.

Again as in the pilot study only the first five topics out of the 9 topics of mathematics 2 were developed sufficiently for use in the CAI tutorials. The 5 topics developed were designed to take the students from the beginning of the semester through to the mid-semester assessment test (posttest) after 7 weeks of instructional time.

### 5.4.2 Research Instruments used in the Main Study

Listed below are the five instruments that were used in the process of data collection in the main study in fulfilling the aims of the present study.

1. Mathematics Attitudes Questionnaire (MAQ)
2. Computer Attitudes Questionnaire (CSQ)
    a) Pre-Computer Experience Questionnaire (CSQ1)
    b) Post-Computer Experience Questionnaire (CSQ2)
3. Mathematics Performance Test
    a) Pretest
    b) Posttest

In contrast to the pilot study where only four instruments were used, five instruments were used in collecting the data in the main study. These were the MAQ, CSQ1, CSQ2, the Pretest and the Posttest. The Pretest was the extra instrument used in the main study that was not implemented in the pilot study because of problems with insufficient time. The instruments are described in detail in section 4.3.3 in chapter 4. The instrument versions used in the main study were slight modifications of the instrument versions used in the pilot study and are described briefly in the sections following below, where they differ from the pilot study versions.

An extra instrument utilised in data collection in both the pilot study and the main study was the final examination. This instrument although not specifically designed for this study was used for data collection and analysis in the present study because of its relevance.

**Instrument 1: Mathematics Attitudes Questionnaire (MAQ)**

The MAQ in the main study was designed as a 40-item, 5 point Likert scale in contrast to the 45-item, 5 point Likert scale in the pilot study. As stated in the description of the pilot study, its purpose was to probe the adult matriculation students' attitudes to mathematics, as a means towards providing a context to their performances in mathematics. A copy of the main study version of the MAQ questionnaire appears in appendix M2.

Items 9, 19, 26, 33 and 34 were dropped from the pilot study version of the questionnaire because of low to negative Corrected Item – Total Correlation coefficients (appendix P3). Pallant (2001) states that corrected item – total correlation coefficient values of less than 0.3 usually indicate that the item could be measuring something different to the scale as a whole. In hindsight items 15, 23 and 35 should also have been dropped from the questionnaire following the pilot study in preparation for the main study.

The sentence structures of all items were personalised following the pilot study with the use of personal pronouns in the item sentence structures so that the students felt more personally addressed in the questionnaire in the main study. It was felt that the students might respond 'better' when the item is addressed to them personally.

All other aspects of the questionnaire were as described in chapter 4, including coding. The only change made to the questionnaire was in the restructure of the response scale described in section 5.4.3 below.

It would have been ideal to pilot the questionnaire again regardless of the extent of the modifications before the main study but this was not possible due to problems with insufficient time.

**Instrument 2 & 3: Computer Attitudes Questionnaires (CSQ1 and CSQ2)**

Both CSQ1 and CSQ2 underwent some modifications after the pilot study in preparation for the main study. Copies of the main study versions of the CSQ1 and CSQ2 questionnaires are presented in appendix M3a and appendix M4a respectively.

The reader will recall from chapter 3 that both the CSQ1 and CSQ2 had very low MSA (Measure of Sampling Adequacy) values in the pilot study rendering them somewhat unsuitable for factor analysis. The aim in the main study therefore was to improve this situation by modifying the questionnaires appropriately. In the end though the decision was made not to perform factor analysis on both questionnaires in the main study as well, although changes aimed at improving the MSA were implemented on the pilot study versions of the questionnaires in preparing the main study versions.

The reasons for not subjecting the two questionnaires to factor analysis in the main study as well are discussed in conjunction with the presentation of the main study results in chapter 6.

The modifications made to the two questionnaires were not based on any particular coefficient derived from the data from the pilot study, as was the case in the MAQ. In the MAQ the Corrected Item – Total Correlation coefficient was used to cull the items, with items having low to negative coefficients being dropped from the questionnaire. In preparing the CSQ1 and CSQ2 for the main study the researcher more or less went through the pilot versions of the questionnaires and removed items which appeared somewhat inappropriate with a better understanding of the situation in hindsight following the pilot study. The changes made are detailed below for each of the two questionnaires.

### CSQ1

Items 9, 12, 18, 21, 24, 28, 29, 30, 33, 34 and 35, about 40 percent of all the items in section B, were dropped from the pilot version of CSQ1. Item 17, which was the same as item 33, was also disregarded in the analysis, although it was included in the main study version of the questionnaire through an oversight.

Additional items in the main study version, which were included following the pilot study, were items 23, 27 and 31. Due to lack of sufficient time these changes were not pilot tested before use in the main study.

### CSQ2

Items 13, 20, 25, 29, 38 and 39 were dropped from the pilot version in preparing CSQ2 for the main study. Items 35, 36, 37, 41, 42, 43 and 44 were additional items to the main study version. The additional items were mainly to do with aspects of tutorial presentation, which the CAI software was supposed to be better designed to handle. These aspects refer to such factors as students' perceptions of imagery (colour, graphics and animation) to enhance mathematics concept building and other physical and conceptual aspects of the software. The other conceptual aspects include such factors as the enhanced capabilities of CAI to facilitate individualised learning as well as navigation from concept to concept and aspects of positive reinforcement such as quick and immediate feedback.

Further to the additions, items 14, 32 and 41 in the main study version were items that were reworded from the pilot version to address the students more appropriately and personally. Item 33 was a repetition of item 26, which slipped through the various checks undetected until the repetition, was noticed during data analysis. To address this problem item 26 was ignored in the analysis while item 33 was included.

### 5.4.3 General Restructure of the MAQ, CSQ1 and CSQ2 for the Main Study

The reader would have noted that the 5-point Likert scale was re-arranged for all three questionnaires in the main study versions. Whereas "NS" for "Not Sure" was physically placed in the middle of the scale in the pilot study versions of the questionnaires, in the main study versions it was placed at the end of the scale. Aside from this physical change in the layout of the response scales the same numerical code value of 3 was given to the "NS" scale point in both the pilot and the main study versions.

The change in the physical layout of the response scales was introduced to 'force' students to make a conscious choice in choosing "Not Sure" instead of choosing it simply because it is in the middle and is the "average" opinion. The reasons for doing this were to reduce as much as possible the level of uncertainty that was a major feature of the two questionnaires in the pilot study.

### 5.4.4 Pretest and Posttest

A copy of the posttest version of the performance test in the main study is in appendix M8. The pretest and the posttest were in actual fact the same test although they were applied as two different tests. With the exception of the changes in the cover page and a rearrangement in the order of the multiple-choice responses (one correct choice plus three distracters), the two versions were in fact the same in every other respect.

To prevent the students from studying the pretest specifically in preparing for the posttest, two measures were taken. Firstly, aside from seeing the test when they sat it as pretest the students did not see it again until the end of the seven weeks of instruction when it appeared again as the posttest. They were not given copies of the test to keep after sitting it as the pretest. Secondly, they were not told that the same test they sat as the pretest would be given again as the posttest at the end of the seven weeks of instruction. Therefore as far as the students were concerned they were two totally different tests.

From experience gained in teaching mathematics 2 students in the past the researcher believes that the two measures taken were sufficient in ensuring the integrity of the posttest. The researcher did not think that seeing the performance test again in the form of the posttest some seven weeks after seeing it as the pretest had a significant bearing on the outcomes of the posttest.

The purpose of having a pre/post arrangement was to compare differences in performance by students before and after instruction for the study population as a whole as well as differences in student performance between the two groups following instruction via the two instructional modes of CAI and TM.

The main study versions (pretest and posttest) of the performance test were the product of the analysis of the data from the posttest in the pilot study. The test items in the posttest in the Pilot study were subjected to facility, difficulty and discrimination analysis in preparing the test for the main study (see appendix P14).

**Summary of Test Procedures and Specifications for the Pretest and Posttest**

1. Application of the pretest before instructions in the course to assess the state of mastery of mathematical concepts in general before undergoing instruction by the two instructional modes.
2. Application of the Posttest after 7 weeks of instruction in the course via CAI or TM.
3. Both tests were designed and applied as 40 item, multiple-choice, objective tests.
4. Both tests were designed as 1 hour and 55 minutes-long tests.
5. Tests were designed to measure both the differences in performances between instructional groups and differences in the students' beginning knowledge and terminal Knowledge after doing the course.

## 5.5 Modifications to the Data Collection Procedures Following the Pilot Study

The discussions in this section concern changes in the procedures for data collection directly resulting from experiences in the pilot study. These changes are mentioned here because they differ somewhat from the original conception of how the study was meant to proceed. It was originally planned to conduct the main study over the entire 14-week semester, as was intended with the pilot study as well. Unfortunately in the case of the pilot study, obstacles encountered in the second semester of 1999 at UPNG forcibly reduced the period to just four weeks, as discussed earlier.

### 5.5.1 Change to the Intended Duration of the Study Due to Observed Attendance Patterns in the Pilot Study

The observed attendance patterns by the CAI students at tutorials during the pilot study indicated that attendance at tutorials steadily declined the longer the period of study went even though it was only a short four week period. Formal attendance records were kept in both the pilot study and the main study and the decreasing attendance pattern was documented in both. The declining attendance at tutorials also became obvious towards the end of the CAI tutorials from the increasing number of unoccupied computers in the laboratory, whereas they were all occupied at the beginning.

The declining attendance pattern is not unusual. In fact this is a normal attendance pattern generally observed with IDCE students at FTF tutorial sessions in various courses and as such is not of any special interest. What was of interest in the declining attendance pattern was the problem that this posed to how the results in the performance test were analysed.

To overcome the problem in the analysis of the data that this situation posed the decision was made to conduct the main study over just 7 weeks rather than over the entire 14 weeks of the semester as originally intended. It was further decided that this 7 weeks period had to be in the first half of the semester in order to allow for the implementation of the pretest before any instructions in the course began. It would then be conveniently terminated by the mid-semester test. This decision was implemented in the main study.

### 5.5.2 Changes to the Intended Results Analysis Procedures Due to Observed Attendance Patterns in the Pilot Study

Another major decision made resulting from the pilot study was the decision to analyse the data from the posttest and the final examination according to the number of CAI tutorials attended by each CAI student. This situation contrasts to that in the pilot study, where the analysis was for the total attendance, at the end of the period of CAI tutorials. It was felt that this would better reflect the real situation as well as pick up nuances in performance outcomes directly related to attendance patterns at tutorials. It was felt that the single analysis just once on the total attendance at the end of the CAI sessions in the pilot study may not have picked up the fine differences introduced by attendance patterns. In the pilot study only those students who attended 2 or more tutorial sessions were included in the CAI group for data analysis and the group was treated as just one sample in contrast to the multiple samples of the main study based on number of attendance at tutorials.

The disadvantage in the multiple-samples-analysis approach in the main study was the problem with the rather small sample sizes that the approach implied.

The justification therefore in adopting the multiple-samples-analysis approach was in terms of a trade-off between the advantages and disadvantages of the approach in the pilot study against the approach in the main study. The following data collection procedures were therefore adopted with these changes in mind.

### 5.5.3 Data Collection Procedures in the Main Study

1. All students enrolling for mathematics 2 were given the Mathematics Attitudes Questionnaire (MAQ) to complete at registration time. The students had to complete the personal information section in the process of completing the MAQ. In order to get as many students to complete the personal information survey and the MAQ, students were allowed to complete the questionnaire right up to the end of the seven weeks of observed instructional time.
2. All mathematics 2 students then sat the pretest before any instructions in the course were given. The first week after registration was set aside for the completion of the pretest because once the tutorial sessions began students could not complete the pretest any more.
3. Students who had enrolled in mathematics 2 were then streamed into the two tutorial mode groups (CAI and TM) for instructional purposes. The streaming was effected through a process of random selection of the CAI students. The rest of the students not selected for CAI were then designated as TM students.
4. Instructions in the course mathematics 2 then ensued for seven weeks with the CAI group being taught via the computer-based method and written materials and the TM group via the usual methods of written materials and face-to-face instructions.
5. Students who were selected for the CAI method of instruction then completed a Pre-Computer Experience Questionnaire (CSQ1) at the beginning of the period of instruction.
6. At the end of the seven weeks of instructional time the students in the CAI group then completed a Post-Computer Experience Questionnaire (CSQ2).

7. All students then sat the posttest, which also doubled as the mid-semester assessment test.
8. Some seven more weeks following the end of the seven weeks of research-related instructions the students sat the final examination in the mathematics 2 course.

## 5.6 General Notes

As it was in the pilot study all survey questionnaire forms were hand-delivered to the students and were either collected back from the students during tutorial times or were returned by the students themselves to the researcher either in person or posted to the researcher's staff pigeonhole. The tests (pretest and posttest) were applied under formal test conditions.

Throughout the period of the seven weeks of data collection the researcher was available to the students (both CAI and TM) in his office for consultation most times during normal working hours, when not involved in CAI tutorials. This was done as a precaution against the introduction of bias to the results in the posttest by being available to the CAI group only. A message to the effect that the researcher would be available to mathematics 2 students in both groups in his office was publicly posted where the students could see it clearly.

Chapter 6 presents the results of the main study as described in this chapter.

# Chapter 6: Results from the Main Study

## 6.1 Introduction

In this chapter the results from the main study are presented. These results are discussed and analysed in the next chapter (Chapter 7). There are ten sections to this chapter. The descriptive results from the MAQ, CSQ1 and CSQ2 are presented in section 6.2. A brief description of the pretest, posttest and the final examination is presented in section 6.3.

Section 6.4 is a description of the factor analysis of the MAQ data. This description includes the rationale for the factor analysis as well as the process of factor analysis employed and the outcome. The validity and the reliability of the constructs derived from the MAQ instrument through factor analysis are also presented in this section.

Section 6.5 presents the results of the statistical tests of hypotheses and differences in attitudes to mathematics between the CAI group and the TM group. The results explore the possibility of statistical bias in the sampling method employed in the main study.

Section 6.6 explores the linkage that might exist between the number of attempts at doing mathematics 2 and performance in the posttest and the final examination. Establishment of an association between the number of attempts and performances, particularly in the posttest, would mean that factors other than tutorial mode were at play. Thus the results would not be addressing the primary purpose of the study i.e. differences in performance due to tutorial mode.

Sections 6.7 and 6.8 argue the cases for the validity and the reliability of the pretest and posttest scales within the context of the mathematics 2 course objectives.

Section 6.9 presents the results of the comparison in performances between the CAI group and the TM group using the Mann Whitney U test on the pretest, the posttest and the final examination.

All statistical analyses in the present study were conducted using the SPSS statistical package. In the main study, both versions 9.0 and 10.0 of the SPSS statistical package were used. Analyses that were completed with version 9.0 before the researcher had access to version 10.0 were kept. The comment made in the pilot study regarding the SPSS statistics packages is re-stated here: apart from the differences in the interface, SPSS versions 9.0 and 10.0 were much the same in the analysis results they produced. The transition from version 9.0 to version 10.0 is somewhat seamless.

## 6.2 Descriptive Results from the MAQ, CSQ1 and CSQ2 in the Main Study

This section presents the descriptive results from the three questionnaire-based instruments used to collect data in the main study.

### 6.2.1 Instrument 1 - MAQ

A copy of the Mathematics Attitudes Questionnaire (MAQ) used in the main study appears in appendix M2a while the summary statistics for the questionnaire are reported in appendix M2b. The MAQ in the main study was a 40 - item questionnaire with a 5-point Likert scale in contrast to the 45-item version in the pilot study. The description of how the 45-item pilot version of the MAQ became a 40-item questionnaire in the main study is provided in chapter 4.

As in the pilot study the main results obtained from the administration of the MAQ were frequency summary tables, which are reported in a summarised form in table 6.1 below. A general summary statistics table, which provided some indication of the attitudes of students in the study sample, is also given in appendix M2b. Results of the statistical tests of hypotheses comparing the attitudes of the CAI group and the TM group to mathematics are presented and described in section 6.5 further on in this chapter.

The results from the MAQ in the main study were also subjected to factor analysis, which is described in section 6.4 further on in the chapter.

*Table 6.1: Frequency Summary Table for the MAQ Likert Scale*

| # | Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 1 | Doing mathematics is a challenge I enjoy. | 95 | 2 | 3 | + |
| 2 | Mathematics is so useful that it should be a required part of my professional skills. | 98 | 1 | 1 | + |
| 3 | I don't like mathematics because it is not relevant to my traditional culture. | 2 | 5 | 93 | - |
| 4 | I think pre-University mathematics as it is taught at present is too foreign and not applicable to PNG students. | 8 | 14 | 78 | - |
| 5 | I think pre-University mathematics is too divorced from PNG traditions and culture. | 9 | 27 | 64 | - |
| 6 | I get a great deal of satisfaction out of solving a mathematics problem. | 97 | 3 | 0 | + |
| 7 | I don't think there is any use for mathematics in PNG traditional culture. | 6 | 10 | 84 | - |
| 8 | It takes me a long time to understand a mathematical concept. | 54 | 6 | 40 | - |
| 9 | Mathematics will be useful to me in my profession. | 95 | 4 | 1 | + |
| 10 | I would like to study advanced mathematics. | 88 | 8 | 4 | + |
| 11 | The thought of taking another mathematics course makes me sick. | 7 | 7 | 86 | - |
| 12 | I find mathematics to be very logical and clear. | 69 | 11 | 20 | + |
| 13 | I have always enjoyed studying mathematics. | 86 | 1 | 13 | + |
| 14 | It is my opinion that mathematics is necessary to keep the world running. | 90 | 8 | 2 | + |
| 15 | I don't think mathematics is important in everyday life. | 5 | 4 | 91 | - |
| 16 | It is my opinion that mathematics has contributed greatly to science and other fields of knowledge. | 98 | 0 | 2 | + |
| 17 | I am interested and willing to acquire further knowledge of mathematics. | 93 | 6 | 1 | + |
| 18 | It is my opinion that mathematics helps to develop a person's mind and teaches him or her to think. | 99 | 1 | 0 | + |
| 19 | I am able to figure out most of the equations I need to solve a mathematics problem. | 74 | 13 | 13 | + |
| 20 | The pace of a mathematics course is so fast that it is impossible for me to learn the subject matter thoroughly. | 48 | 15 | 37 | - |
| 21 | Mathematics ideas exist in my home culture. | 60 | 31 | 9 | + |
| 22 | Methods of solving mathematics problems are useful in my home culture. | 56 | 33 | 11 | + |
| 23 | Mathematics for me is about useful and practical ideas. | 100 | 0 | 0 | + |
| 24 | Mathematics is very interesting and I have usually enjoyed courses in this subject. | 88 | 4 | 8 | + |
| 25 | There are no useful mathematical ideas in traditional cultural activities. | 14 | 28 | 58 | - |
| 26 | I enjoy going beyond the stated course and trying to solve new problems in mathematics. | 83 | 9 | 8 | + |
| 27 | I would like to develop my mathematics skills and study this subject more. | 95 | 3 | 2 | + |
| 28 | It is my opinion that an understanding of mathematics is needed by artists and writers as well as scientists. | 89 | 8 | 3 | + |
| 29 | I think that mathematics is less important to people than art or literature. | 6 | 12 | 82 | - |
| 30 | I consider mathematics to be dull and boring because it leaves no room for personal opinion. | 6 | 10 | 84 | - |
| 31 | I have never liked mathematics and it is my most dreaded subject. | 11 | 5 | 84 | - |
| 32 | Mathematics makes me feel uneasy and confused. | 30 | 4 | 66 | - |
| 33 | Mathematics for me is a worthwhile and necessary subject. | 92 | 2 | 6 | + |
| 34 | Mathematics makes me feel uncomfortable and nervous | 23 | 4 | 73 | - |
| 35 | I do not need mathematics to survive in the village. | 16 | 13 | 71 | - |
| 36 | I think that mathematics is useful in traditional societies. | 66 | 22 | 12 | + |
| 37 | I would avoid mathematics completely if that was possible and I could still continue my studies. | 13 | 6 | 81 | - |
| 38 | Mathematics is unnecessary in my chosen profession. | 5 | 4 | 91 | - |
| 39 | There are so many mathematical concepts to learn that I get confused. | 61 | 5 | 34 | - |
| 40 | Given the opportunity, I would take another mathematics course even though it were not required. | 78 | 6 | 16 | + |

Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree

While the results presented in table 6.1 still showed some uncertainty in the response patterns, in contrast to the results in the pilot study, there was generally less uncertainty shown in the response patterns in the main study. Uncertainty levels as shown by the frequency of "NS" responses of greater than 15 percent (≥ 15) were recorded in items 5, 20, 21, 22, 25 and 36, about 15 percent of the items, in contrast to 40 percent of the items in the pilot study. This improvement in response patterns is the result of the removal of the 5 items from the pilot study version of the MAQ questionnaire that had low to negative Corrected Item – Total Correlation coefficients. It appears that the measures taken following the pilot study to improve the MAQ questionnaire as a data-collection instrument in preparation for the main study did pay off to a general extent.

As for the pilot study, almost all the items in which there was a high level of "NS" responses were those on the relevance of mathematics in the cultural context. It therefore appears that students, in the study sample at least, do mathematics because they perceive that it is important to their learning regardless of the cultural relevance of mathematics.

Again, as shown in the pilot study in table 4.5, table 6.1 shows that the students in the research population had a decidedly positive attitude to mathematics. Appendix M2b confirms this generally positive student attitude to mathematics by the rather high median response value for each of the 40 items. With the exception of items 8, 20 and 39, the medians of all other items were either 4.0 or 5.0.

The reliability analysis of the scales was conducted in conjunction with factor analysis and is therefore discussed in the relevant section (6.4.2.4) further on in the present chapter.

The only items in which there was a clear level of ambivalence in student responses were items 8, 20, 32 and 39 where equally high numbers of students agreed as disagreed. All four items were dealing with the difficulty of mathematics as a subject. Item 8 in the main study was also item 8 in the pilot study and the response to this item in the main study was very similar to that in the pilot study. The conclusion reached in the pilot study therefore, in commenting on item 8, that the students' response pattern was most probably a reflection of the reality of the difficulty of mathematics as a subject, also applies here.

### 6.2.2 Instrument 2 - CSQ1

A copy of the Pre-Computer Experience Attitudes Questionnaire (CSQ1) used in the main study appears in appendix M3a while the frequency tables and charts for section A (Items 3, 5, 6 & 7) are reported in appendix M3b. Appendix M3c reports the summary statistics for the 23 items of the questionnaire. The response frequency summaries for the CSQ1 Likert scale (Section B) are summarised and reported in table 6.2 below.

Item 2 in section A of CSQ1 which asked the students to state their reasons for volunteering for CAI was ignored in the analysis for reasons already discussed in section 4.7.2 in chapter 4.

The response to item 3 (*I have used a computer before*) in the main study was similar to that in the pilot study. The results show that at least 55 % (65% in the pilot study) of the CAI sample had none to very minimal experience with computers prior to this study. As in the pilot study, given this situation it was difficult to see how the students would have formed reliable and valid attitudes to computers and the CAI software as expressed in their responses to the items in the Likert scale.

The response pattern to item 3 somewhat limited the scope of the usefulness of the data from the CSQ1 questionnaire because it invalidated any comparison with the results from CSQ2 on common items. The data from CSQ1 was therefore not subjected to factor analysis just as in the pilot study but was used to basically note and comment on the general trends in attitudes of the sample to the use of computers and the computer-based mathematics software that stood out.

Item 4, which is related to item 3, was ignored in the analysis as in the pilot study and the reasons for this are also discussed in section 4.7.2 in chapter 4.

There were no problems associated with the use of the mouse as shown by the response to item 5 where all of the students found it easy to very easy. Item 6 shows that 35 percent of the students found the use of the computer keyboard difficult to very difficult and from item 7 it was concluded that reading text on screen was not a problem at all except to about 3 percent of the students.

Table 6.2 below is a summary of the frequency tables for the 23 items in the CSQ1 Likert scale. There are roughly equal numbers of positively worded and negatively worded items in the scale.

***Table 6.2: Frequency Summary Table for the CSQ1 Likert Scale***

| # | Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 9 | Computers can help me improve my understanding of mathematics. | 91 | 9 | 0 | + |
| 10 | I consider computers to be valuable tools for learning. | 100 | 0 | 0 | + |
| 11 | I think the world would be better off if computers have never been invented. | 6 | 3 | 91 | - |
| 12 | I think learning mathematics using CAI is quicker and easier for me. | 80 | 14 | 6 | + |
| 13 | I think learning mathematics through CAI lacks the sense of presence that a human tutor provides. | 43 | 14 | 43 | - |
| 14 | I would rather attend face-to-face tutorials with a human tutor than go through CAI. | 26 | 8 | 66 | - |
| 15 | I would like to see more IDCE courses taught through CAI. | 80 | 17 | 3 | + |
| 16 | I think learning mathematics through CAI would be much better than learning it from course booklets. | 60 | 20 | 20 | - |
| 17 | I am joining CAI because it is a chance to use and handle computers and not necessarily to learn mathematics | 11 | 3 | 86 | - |
| 18 | CAI can be a very useful way of learning mathematics if it is properly implemented. | 97 | 3 | 0 | + |
| 19 | It is my opinion that CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorials. | 14 | 26 | 60 | - |
| 20 | I don't think CAI can work in PNG because Papua New Guineans lack computer skills. | 17 | 11 | 72 | - |
| 21 | I think CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | 3 | 12 | 85 | - |
| 22 | I think CAI would be better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | 66 | 23 | 11 | + |
| 23 | CAI allows me to go through my maths lessons the way I like and at my own pace. | 89 | 8 | 3 | + |
| 24 | I think learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | 83 | 17 | 0 | + |
| 25 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through CAI. | 0 | 6 | 94 | - |
| 26 | I can learn mathematics better from a book in front of me than from a computer screen. | 26 | 20 | 54 | - |
| 27 | Working at my own pace using CAI is not as effective in learning mathematics as attendance at face-to-face tutorials. | 20 | 14 | 66 | - |
| 28 | I don't think CAI is as effective in mediating learning in mathematics 2 as course booklets. | 17 | 14 | 69 | - |
| 29 | I don't think CAI is as effective in mediating learning in mathematics 2 as face-to-face tutorials. | 18 | 18 | 64 | - |
| 30 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | 23 | 17 | 60 | - |
| 31 | I am joining CAI because I prefer to work through my maths lessons at my own pace rather than that of a tutorial group. | 80 | 6 | 14 | + |
| | Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree | | | | |

Table 6.2 shows that only items 16, 19, 22 and 26, less than 20 percent of the items, show an uncertainty level of 20 percent or more, in contrast to 40 percent in the pilot study results of CSQ1. The uncertainty level is shown by the rate of "NS" responses. No items show an "NS" response rate of 30 percent or more in table 6.2 in contrast to a rate of 25 percent in the equivalent data in the pilot study. The only explanation that comes to mind for this seemingly improved response pattern in CSQ1 in the main study in contrast to that in the pilot study is the effort put into

improving the CSQ1 questionnaire following the pilot study. It appears that the efforts made in improving CSQ1 before the main study paid off to the extent that the items invited more definitive responses from the students than in the pilot study.

Only Item 13 shows a lack of a clearly identifiable tendency in that about equal numbers of students agreed as disagreed, whereas about eight items had that problem in the pilot study version of CSQ1. It is therefore quite clear that the students sampled in the CAI sample in the main study regarded the use of computers and computer-based mathematics software extremely positively.

The scale of 23 items in the CSQ1 Likert scale was subjected to Cronbach's Alpha reliability test, as reported in appendix M3d. The overall measure of internal consistency for the 23 items of the CSQ1 was about 0.86 compared to 0.79 in the pilot study. A reliability coefficient of 0.86 falls well above the critical value of 0.7 thereby providing strong support to the reliability of the overall scale as a measure of a construct. While it is not possible to identify this construct exactly, it is interpreted and labelled here as a generally positive attitude to computers and the computer-based mathematics software.

On the basis of a Cronbach's Alpha reliability coefficient level of 0.86, summary statistics as reported in appendix M3c were produced. The summary statistics generally confirm what was noted in the responses to section A of CSQ1 and the Likert scale that the students had positive attitudes to computers and the computer-based mathematics software and that they were well disposed towards the use of computers for learning purposes in general. The median (see Chapter 4 on the reasons for using the median rather than the mean) value for each of the 23 items in the Likert scale was either 4.0 or 5.0. The exception was item 13, which had a median of 3.0. Item 13 is the item identified above in which the CAI students showed a lack of a clear tendency in attitudes with equal numbers of students agreeing as disagreeing.

Again, these statistical result have to be viewed within the confines of the reservations already expressed in regard to the students' lack of adequate exposure to computers as portrayed in both the pilot and the main study responses to item 3 in CSQ1.

### 6.2.3 Instrument 3 – CSQ2

A copy of this questionnaire appears in appendix M4a and the frequency summary tables for each item in this questionnaire are summarised and reported in appendix M4b for section A and table 6.3 below for section B (Likert scale). Section A consisted of 6 general items on their basic computer skills level (items 2 - 4) and how the students felt about the CAI experience (items 5 - 7) after having undergone seven weeks of computer-based mathematics tutorials. Section B consisted of 37 items in a 5-point Likert scale on students' attitudes after the 7-week CAI tutorial experience.

Items 2, 3 and 4 (appendix M4b) in CSQ2 were similar to items 5, 6 and 7 (appendix M3b) in CSQ1 on the use of the mouse (Item 2) and keyboard (Item 3) and the comparative ease of reading a line of text on-screen (Item 4). Generally, the patterns of response on items 2, 3 and 4 were similar in CSQ1 and CSQ2. Almost all students had no problems with the use of the mouse and reading text on-screen and about 30 percent of the students found the use of the keyboard difficult, a pattern noted also in CSQ1in the main study as well as in both instruments in the pilot study. As it was in the pilot study, the researcher's own observations during the CAI tutorials suggested that many students did not have much experience with computers from the way they handled the mouse and the keyboard at the start. But it was also observed that students picked up those skills quickly and by the end of the 7 weeks of tutorials they were reasonably comfortable in using the mouse in particular, and the keyboard, to the skills level required.

In response to item 5 (*Were the CAI lessons easy to use?*) and item 6 (*Were you happy with the amount of control you had over the CAI lessons?*) more than 80 percent (about 90 % in the pilot study) responded in the affirmative to both items. Item7 (*Do you think you learn faster and better on the computer?*), which was item 6 in the pilot study version of CSQ2, showed a noticeable difference in the response pattern. Whereas about 80 percent of the students responded in the affirmative in the pilot study only about 65 percent responded in the affirmative in the main study.

The pilot study, as the reader would recall from the discussions in chapters 3 and 4, was conducted over a 4-week period only whereas the main study was conducted over a 7-week period. The 4-week period may have been too short a period of time for the students to get over the initial novelty aspect of using a computer-based mode of instruction for the first time, whereas the 7–week period in the main study was sufficient time to give the students a better and more balanced view of the mode of instruction itself external to the medium of instruction. The students may have realized after the seven weeks period that learning mathematics requires effort regardless of the medium of instruction so that there was less euphoria about the medium of instruction.

Table 6.3 below is a summary of the response frequency summary tables for the thirty-seven items in the CSQ2 Likert scale.

Table 6.3 shows that only item 21, 31 and 44, less than 10 percent of all items, showed uncertainty levels of 20 percent or more (≥20%). In contrast to this just under 20 percent of the items in CSQ1 in the main study and about 30 percent of the items in CSQ2 in the pilot study showed "NS" rates of 20 percent or more (≥20%). The uncertainty level is shown by the rate of "NS" responses. No items in CSQ2 in the main study (table 6.3) shows an "NS" response rate of 30 percent or more (≥30%) whereas two items in CSQ2 in the pilot study showed an "NS" rate of at least 30 percent.

The trend of an improvement in response patterns in CSQ2 compared to CSQ1 was also noted in the pilot study. Exposure to computers appeared to make the students more confident of their view of computers and the computer-based mathematics software. The lack of a clear tendency in student responses was evident in item 15 only where roughly equal numbers of students agreed as disagreed.

*Table 6.3: Frequency Summary Table for the CSQ2 Likert Scale*

| # | Questionnaire Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| 9 | It is easier for me to read a line of text on a page in a book than on the screen. | 23 | 8 | 69 | - |
| 10 | Computers have helped me improve my understanding of mathematics. | 83 | 8 | 9 | + |
| 11 | The CAI-based mathematics 2 course has helped me improve my understanding of the contents of the course. | 94 | 3 | 3 | + |
| 12 | I consider computers to be valuable tools for learning. | 100 | 0 | 0 | + |
| 13 | Learning mathematics using CAI is quicker and easier for me. | 80 | 8 | 12 | + |
| 14 | I would take another mathematics course through CAI having had this experience. | 94 | 3 | 3 | + |
| 15 | Learning mathematics through CAI for me lacks the sense of presence that a human tutor provides. | 49 | 8 | 43 | - |
| 16 | I would rather attend face-to-face tutorials with a human tutor than go through CAI again. | 20 | 14 | 66 | - |
| 17 | I would like to see more IDCE courses taught through CAI. | 88 | 6 | 6 | + |
| 18 | Learning mathematics through CAI for me is much better than learning it from course booklets. | 69 | 14 | 17 | + |
| 19 | I believe the time has come for computer applications like CAI in Papua New Guinea. | 91 | 9 | 0 | + |
| 20 | It is my oipinion that CAI as a mode of learning in distance education in PNG should be pursued more vigorously. | 94 | 6 | 0 | + |
| 21 | I find CAI to be less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorial. | 14 | 20 | 66 | - |
| 22 | I don't think CAI can work in PNG because Papua New Guineans lack computer skills. | 6 | 6 | 88 | - |
| 23 | I think CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | 0 | 3 | 97 | - |
| 24 | CAI is better in mediating mathematics learning for me than other more traditional mediums such as course booklets and face-to-face tutorials. | 63 | 11 | 26 | + |
| 25 | I think learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | 88 | 6 | 6 | + |
| 26 | I would like to learn how to use the computer more effectively. | 100 | 0 | 0 | + |
| 27 | It is my opinion that computers can really make one's life more difficult. | 6 | 6 | 88 | - |
| 28 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through CAI. | 3 | 3 | 94 | - |
| 29 | I can learn mathematics better from a book in front of me than from a computer screen. | 17 | 11 | 72 | - |
| 30 | The colour, graphics and animation in CAI has made the learning of concepts in mathematics 2 interesting and easy for me. | 86 | 8 | 6 | + |
| 31 | I think CAI is more effective in mediating learning in mathematics 2 than course booklets. | 68 | 23 | 9 | + |
| 32 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | 97 | 3 | 0 | + |
| 33 | I would like to learn how to use the computer more effectively. | 100 | 0 | 0 | + |
| 34 | I consider CAI to be less effective in mediating learning in mathematics 2 than course booklets. | 6 | 17 | 77 | - |
| 35 | Being able to work at my own pace in covering the units in mathematics 2 is one aspect of CAI I find useful. | 91 | 6 | 3 | + |
| 36 | The navigation capabilities provided in the CAI software has made my mathematics learning enjoyable and effective. | 91 | 3 | 6 | + |
| 37 | Mathematics comes alive for me when taught through CAI. | 89 | 8 | 3 | + |
| 38 | Concepts in mathematics that I found difficult before are clearer when presented through CAI. | 88 | 6 | 6 | + |
| 39 | The navigation capabilities provided in the CAI software is clear and logical so that I know exactly where I am in the CAI-mediated mathematics lessons. | 88 | 9 | 3 | + |
| 40 | The colour, graphics and animation in CAI is distracting for me making CAI less effective as a learning tool. | 3 | 3 | 94 | - |
| 41 | The capability of CAI to provide immediate feedback is no different to looking up the answers to exercises provided in the back of a unit booklet. | 63 | 8 | 29 | - |
| 42 | The navigation capabilities provided in the CAI software makes no difference for me in learning mathematical ideas. | 54 | 11 | 35 | - |
| 43 | The ability of the CAI software to provide immediate feedback in the exercises provided in some topics has increased my interest and effectiveness in mathematics 2. | 91 | 3 | 6 | + |
| 44 | Working at my own pace using CAI is not as effective in learning mathematics as attendance at face-to-face tutorials. | 11 | 20 | 69 | - |
| 45 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | 20 | 11 | 69 | - |
| | Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree | | | | |

The highly positive attitudes of students to computers and the computer-based mathematics software as shown in the pilot study and in CSQ1 in the main study is again reiterated in the results in this questionnaire. The overwhelming evidence from the data in both the pilot study and the main study, amongst students in the CAI sample at least, is that their view on the use of computers for learning purposes is extremely positive. Students were willing and eager to take on the challenges of the computer-based mode of learning mathematics and explore the possibilities offered by that mode of learning.

The scale of 37 items in the CSQ2 Likert scale was subjected to Cronbach's Alpha reliability test, as reported in appendix M4d. The overall measure of internal consistency for the 37 items of the CSQ1 was about 0.90 compared to 0.86 for the CSQ1 in the main study and 0.88 for CSQ2 in the pilot study. A reliability coefficient of 0.90 falls well above the critical value of 0.7 thereby providing strong support to the reliability of the overall scale as a measure of a construct. Again as in CSQ1 as described in section 6.2.2 that while it is not possible to identify this construct exactly, it is interpreted and labelled here as a generally positive attitude to computers and the computer-based mathematics software.

On the basis of a Cronbach's Alpha reliability coefficient level of 0.90, summary statistics as reported in appendix M4c were produced. The summary statistics generally confirm what was noted in the responses to section A of CSQ2 and the Likert scale that the students had positive attitudes to computers and the computer-based mathematics software and that they were well disposed towards the use of computers for learning purposes in general. The median (see Chapter 4 on the reasons for using the median rather than the mean) value for each of the 37 items in the Likert scale was either 4.0 or 5.0. The exceptions were items 15, 41 and 42 where the medians were 3.0, 2.0 and 2.0 respectively.

Again it is restated here that these statistical results need to be viewed within the confines of the reservations expressed repeatedly in regard to the students' lack of adequate exposure to computers as portrayed in both the pilot study (CSQ1 and 2) and the main study (CSQ1) results.

## 6.3 The Mathematics Performance Tests – The Pretest and the Posttest

### 6.3.1 Instrument 4 and 5 (Pretest and Posttest)

The pretest and the posttest differed only in two respects. The first was in their cover pages. The cover page in the pretest had a different title to that in the posttest. The second was in the order of the multiple choices (correct answer plus 3 distracters). The order in the posttest was different from that in the pretest. The students were not told at anytime that the two tests were the same. Only the researcher, the mathematics coordinator of IDCE and the only other tutor who assisted the researcher with the CAI tutorials knew this fact.

A copy of this test appears in appendix M5. Only the Posttest form of the achievement test is included in the appendix given that the tests were identical. The results from these two tests were used to test the hypotheses generated for this study, with respect to the efficacy of CAI as a mode of instruction compared to the traditional mode of instruction. The statistical tests of hypotheses on the performances of the CAI and TM groups on the pretest and posttest are presented in section 6.10.

### 6.3.2 Mathematics 2 Final Examination

A "$6^{th}$" instrument used to assess the students' comparative performances with respect to mode of instruction was the semester 1, 2000 Final Examination in mathematics 2. In the pilot study the semester 2, 1999 final examination in the mathematics 2 course was similarly used. This instrument though not specifically designed for this study was used because its results were relevant to the aims of the present study, as a point of comparison with the Posttest. It compared the performances of students in the two groups some 7 weeks after the CAI instructions had been completed. The comparison of the effects of the modes of instruction after a time lag was used to determine whether CAI-based teaching made any difference to students' retention of mathematical concepts in the longer term, compared with the more traditional mode of instruction.

## 6.4 Factor Analysis for the MAQ Data

Only one questionnaire, the MAQ was subjected to factor analysis in the main study. Neither CSQ1 nor CSQ2 was subjected to factor analyses because of problems similar to those in the pilot study that led to the decision not to subject them to factor analysis. This is regardless of the fact that the versions of CSQ1 and CSQ2 used in the main study were improved versions of the pilot study versions.

Discussion on the rationale for and the aspects and processes of factor analysis employed in the main study to factor analyse the MAQ response data is presented in the following sections.

### 6.4.1 Rationale for Factor analysis of the MAQ Data

This section provides a simplified and brief discussion of the concept of factor analysis in multivariate statistics and the rationale for the use of the particular aspects of factor analysis used in the present study in analysing the MAQ data. The discussion is solely to provide an explanation and justification for the particular analysis procedures applied in the present study.

Factor analysis refer to a large variety of procedures which are aimed at summarising a large set of inter-correlations amongst variables in terms of a smaller number of underlying unobservable variables or factors as noted for instance by (Gable and Wolf (1993), Everitt and Dunn (1991), Hair et al. (1987) and Nunnally (1967). Researchers in developing and evaluating tests and scales extensively use factor analytic techniques to identify what the underlying factors are in a large set of variables in order to identify 'clumps' or groups among the inter-correlations as noted for instance by Pallant (2001). The SPSS statistical package lists factor analysis under data reduction techniques because of the fact that it is used to 'reduce' or summarise a large number of variables to a smaller set of more interpretable coherent factors that are relatively independent of one another (Tabachnik and Fidell (2001)).

Factor analysis is particularly important in the explication of constructs and is a crucial aspect of construct validation (Tabachnik and Fidell (2001); Nunnally (1967)). The aspect of construct validation was in fact the main reason behind the decision to use factor analysis to analyse the MAQ data in the present study. The factors were used to establish the validity of the underlying constructs in the MAQ data (see section 6.4.2.5).

As suggested by Everitt and Dunn (1991) and numerous others, factor analysis covers a large variety of procedures. Stevens (1996) lists two main empirical approaches to factor analysis, principal component analysis (PCA) and factor analysis (FA). He states that both methods often yield similar results but that the principal component method is preferred. Amongst the four reasons he gives for this are that it is a psychometrically sound procedure and that it is simpler mathematically, relatively speaking, than factor analysis. Tabachnik and Fidell (2001) in providing the rationale for choosing PCA over FA in a given research situation state that if the researcher simply wanted an empirical summary of the data set, PCA is the better choice.

SPSS version 10.0 lists 7 methods, which include Principal Components Analysis, Principal Axis Factoring and Alpha Factoring among them. In the present study the method of Principal components was used.

#### 6.4.1.1 Deciding on the Factors to Retain

A question that arises once the method of analysis is decided on and the factors extracted is how many components or factors to retain. This can be a difficult question to answer because with poorly correlated data, especially those derived from relatively small samples such as was the case in the present study, the factors can be difficult to determine. The decision on which factors to retain and which to discard, is normally based on the percentage of variance explained by each factor.

According to Stevens (1996) as many factors as will account for a specified amount of total variance should be retained. He suggests this specified amount of total variance to be at least 70 percent.

Two methods often used to determine this are Kaiser's Criterion and the Scree-Test Criterion. Everitt and Dunn (1991) and Stevens (1996) state that a popular criterion often used is to accept all factors with eigenvalues greater than unity. Everitt and Dunn (1991) further suggest that this criterion appears to work well when applied to samples from artificially created population models. Stevens (1996) and SPSS refer to this criterion as Kaiser's Criterion. Stevens (1996) states that the Kaiser

Criterion has been shown to be quite accurate when the number of variables is $<30$ and the communalities are $> 0.7$, or when $N>250$ and the mean communality is $\geq 0.6$. One problem often noted with using Kaiser's Criterion, is that often it results in the extraction of too many factors, which are often difficult to interpret. To overcome this problem a very useful informal method of factor extraction suggested by Cattell (1966) is often used.

Cattell suggested the use of the scree-test criterion, which uses a graph of the eigenvalues. The factors before the graph flattens out noticeably (scree) are retained in this method while the rest are discarded. This method is also available using SPSS.

A complicating consideration in factor analysis is the sample size. According to Pallant (2001) there is little agreement on the recommended sample size. Some authors (e.g. Stevens (1996)) suggest using some ratio such as cases or subjects per item. Generally most researchers agree that the greater the sample size the more reliable the results are likely to be.

#### 6.4.1.2 Deciding on the Method of Rotation of Retained Factors

Quite often the extracted factors are not easily interpretable and are then subjected to some form of rotation. There are two major classes of rotation: orthogonal (rigid) and oblique. In orthogonal rotation the factors obtained after the rotation are assumed to be independent of each other whereas in oblique rotation the assumption is that they are related. SPSS provides a number of different orthogonal rotations including varimax, which is the most commonly used form of orthogonal rotation.

The most common method of oblique rotation available through SPSS is the Direct Oblimin method of rotation. According to Stevens (1996) many have argued that correlated factors are much more reasonable to assume in most cases especially with attitude questionnaires such as the MAQ. This implied that the method of Direct Oblimin was more appropriate.

However, in the present study Varimax rotation was used in the analysis of the MAQ data because the Direct Oblimin method of rotation failed to converge in the required number of iterations whereas the varimax rotation method did.

#### 6.4.1.3 Factor Loadings used in the Interpretation of the Retained Factors

Factor loadings refer to the correlation between the variable and the factor. Without going into the mathematical arguments for it, according to Stevens (1996) a rough check on whether a loading is statistically significant is to double the standard error i.e. doubling the critical value required for significance for an ordinary correlation. The critical value for a correlation coefficient at $\alpha = 0.01$ for a two-tailed test in a sample of 100 according to Stevens is 0.256. Accordingly the suggestion to double the standard error implies that for the MAQ data for instance only factor loadings > 2 (0.256) = 0.512 are acceptable. This is a departure from the usual practice of many researchers of accepting as a rule of thumb all factor loadings greater than ±0.3 as significant regardless of sample size as noted for instance by Hair et al. (1987). In the present study both the approaches suggested are considered in extracting the factors retained for the MAQ data.

### 6.4.2 Extracting Factors from the MAQ Data using Principal Component Analysis

#### 6.4.2.1 MAQ Factors or Constructs as Originally Conceived

The items in the MAQ were generated with certain constructs or factors in mind which were built into the design of the MAQ initially. Table 6.4 below tabulates these factors or constructs as they were originally conceived with their Cronbach's Alpha coefficients listed.

On the basis of 0.7 as the acceptable minimum Cronbach's Alpha level for a questionnaire such as the MAQ (Francis, 1999) it is obvious that factors 5 and 6 in table 6.4 fail the test for acceptability. They are both less than the minimum level of 0.7 required for acceptability. By the same token factors 1, 2, 3, 4 and 7 fulfilled the reliability requirement and are therefore acceptable.

*Table 6.4: Factors or Constructs as Originally Conceived*

| Factor | Descriptive Title | Item | Cronbach's Alpha |
|---|---|---|---|
| 1 | Overall view of mathematics | All 40 items | 0.8836 |
| 2 | Interest in further development of mathematical skills | 1, 10, 11,17, 26, 27, 31, 32, 34, 37, 40 | 0.7944 |
| 3 | Enjoy doing mathematics | 1, 6, 11, 13, 24, 30, 31, 32, 34 | 0.7463 |
| 4 | Relevant to PNG cultural context | 3, 4, 5, 7, 21, 22, 25, 35, 36 | 0.7812 |
| 5 | Mathematics is useful | 2, 7, 9, 16, 18, 22, 23, 25, 29, 36 | 0.6241 |
| 6 | Mathematics is Necessary | 14, 15, 16, 28, 29, 33, 35, 38 | 0.6117 |
| 7 | Mathematics is Difficult | 8, 12, 19, 20, 31, 32, 34, 37, 39 | 0.7904 |

#### 6.4.2.2 Principal Component Analysis of the MAQ

The MAQ data was then subjected to factor analysis to determine whether the underlying constructs as originally conceived had any similarities to the factors extracted in the factor analysis. As discussed in the foregoing sections the method of factor analysis chosen was that of Principal Component Analysis (PCA) with Varimax rotation. Discussion on factor loading for the rotation is presented in the next section (6.4.2.3).

The reader will recall that in the pilot study factor analysis could not be performed on the MAQ data because of a less than adequate MSA (Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA) (Kaiser, 1970). The MAQ data in the main study was also subjected to the MSA requirement and Bartlett's test of Sphericity (Bartlett, 1954) and it was found on both counts that the MAQ data was suitable for factor analysis. Values of MSA $\geq 0.6$ are required for good factor analysis. Bartlett's test for sphericity tests the hypothesis that the correlations in a correlation matrix are zero i.e. there are no correlations amongst the variables at all. Table 6.5 below sets out the results of these two tests for the MAQ in the main study.

**Table 6.5: KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .605 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1554.310 |
| | df | 780 |
| | Sig. | .000 |

Table 6.5 shows that the MAQ data in the main study is just adequate for factor analysis with an MSA > 0.6. Bartlett's test of sphericity is also significant implying that there are significant correlations in the correlation matrix. This then provided the justification for factor analysis to be carried out on the MAQ data in the main study using principal component analysis.

Given that the MSA was just adequate there were concerns that the MAQ scale could still not be that adequate for factor analysis. In fact this concern was borne out in the resulting correlation patterns as they appeared in the validity analysis of the four factors extracted (see appendix M7).

The various tables generated, in effecting the process of principal component analysis in extracting the factors from the MAQ data, are reported in appendix M5. These results include the table of communalities (appendix M5a) for the 40 items, the table of eigenvalues explaining total variance (appendix M5b) and the scree-plot (appendix M5c).

Principal Component Analysis using Kaiser's Criterion produced 12 components. This was considered as far too many factors, which were not very easy to interpret. The factors were then examined with reference to Catell's (1966) scree-plot test. Using this test only the first four of the twelve factors were retained because the graph decidedly flattens out after the first four factors.

### 6.4.2.3 Results from the Rotation of the Four Factors retained from the MAQ Data

For the rotation a factor loading of 0.3 was set for the MAQ data initially but it was found that the factors were still too difficult to interpret even after the factors had been rotated. The factor loading was then set at 0.49, which was somewhat of a compromise between 0.30 and the 0.512 calculated in section 6.4.1.3 as appropriate to a sample size of 100. This compromise was the result of some exploratory analysis conducted on the data.

The four factors retained were then rotated using the orthogonal varimax rotation under the factor loading conditions as described above. The results from the rotation are reported in appendix M6b, which clearly shows each factor distinctly, making interpretation easier. Appendix M6b also reveals that under the above factor loading conditions fourteen (14) variables (items) did not sufficiently correlate with any of the four factors at all. Therefore the original 40-item MAQ questionnaire effectively became a 26-item questionnaire under the set factor analytic conditions.

A drawback due to retaining only four factors, which is obvious from appendix M6a, was the fact that the four factors explained only around 41percent of the variance. Comparing this to Stevens' (1996) suggestion to retain as many factors as would account for as much as 70 percent of the variance, the 41 percent variance accounted for by the four factors retained is rather poor. But the researcher accepted this drawback as the least of all evils inherent to the data. In retrospect the questionnaire could have been designed better and piloted more thoroughly beforehand even though it was an improvement on the version used in the pilot study.

#### 6.4.2.4 Interpretation, Description and Reliability of Extracted Factors

Table 6.6 below lists the factors that were extracted as well as two overall factors. These were the theoretical constructs that were tested for the MAQ data in the main study. The two overall factors are, the overall factor consisting of all 40 items in the MAQ questionnaire and the overall factor consisting of the 26 items used in the four extracted factors. Descriptive labels as interpreted by the researcher were then given to each of the six factors and are shown in table 6.6.

From table 6.6 it is clear that all the scales for the six factors, including the four that were extracted (Extract 1, 2, 3 & 4), at the least, satisfied the minimum level of Cronbach's Alpha for reliability. Although looking at all four extracted factors they were all quite close to the minimum requirement for reliability of 0.7 and in the case of extracted factor 4 it just satisfied the minimum level of 0.7. However aside from this problem there is sufficient evidence to support the internal consistency of the factor scales as measures of 'real' constructs.

***Table 6.6: Factors or Constructs as Extracted (Extract 1, 2, 3 & 4) from Factor Analysis plus overall factors***

| Factor | Descriptive Title | Item | Cronbach's Alpha |
|---|---|---|---|
| Ovearll1 | Overall view of mathematics (40 items) | All 40 items | 0.8836 |
| Overall2 | Overall View of Mathematics (27 Items) | 2, 6, 7, 9, 10, 12, 15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 29, 30, 31, 32, 34, 35, 36, 38, 39 | 0.8400 |
| **Extract1** | **Mathematics is relevant to traditional culture** | **7, 15, 21, 22, 25, 29, 30, 35, 36** | **0.7730** |
| **Extract2** | **Mathematics is confusing** | **12, 19, 20, 26, 32, 34, 39** | **0.7991** |
| **Extract3** | **Mathematics is important** | **6, 16, 17, 18, 27, 38** | **0.7279** |
| **Extract4** | **Mathematics is useful** | **2, 9, 10, 31** | **0.7095** |

It is also abundantly clear in comparing the factors in tables 6.4 (pre-conceived factors) and the factors in table 6.6 (extracted) that there is very little similarity in the items which make up the particular factors aside from the overall view derived from the 40 items. The labelling of the extracted factors in table 6.4 is not too different from those in table 6.6 but the items that support each factor are quite different. The only extracted factor in table 6.6 that bore some resemblance to one of the pre-conceived constructs in table 6.4 was the one on the relationship between mathematics and traditional culture.

The instrument (MAQ) therefore did not perform as expected by the researcher in the main study remembering that it was not subjected to factor analysis in the pilot study. Further statistical consideration of the originally conceived constructs in table 6.4 was therefore abandoned because there was no basis for the validation of those scales. The validation of the extracted constructs is presented in the next section.

### 6.4.2.5 Validity Concerns for the Extracted Factors or Constructs in the MAQ

The main reason for conducting factor analysis was to facilitate the process of validation of the constructs. The validated constructs were then used to refine the hypotheses generated on the attitudes of distance education, matriculation students to mathematics. As noted in chapter 4 the validity of the MAQ could only be argued on the basis of the representativeness of the items that supported the underlying constructs in the questionnaire data. In the main study this was done using the concepts of convergent and discriminant validity which is one way of establishing construct validity for a scale (Trochim, 2000). Convergent validity postulates that measures or items, which are related, should show high inter-correlations. Discriminant validity on the other hand postulates that measures or items, which are not related, should show low inter-correlations.

Appendix M7 reports the Spearman Rank correlation coefficients arranged in a table in such a way as to show convergent and discriminant validity. These correlations were transcribed from an SPSS correlation output matrix, which was too big to include in the appendix. The correlation matrix is presented as a mapping of areas of significant correlations and areas of non-significant correlations. The SPSS correlation output provides information on the significance of correlation coefficients at both the 0.01 level and 0.05 level and this information was used to produce the mapping in appendix M7.

From the correlation mapping in appendix M7 it can be concluded that the four constructs extracted in the factor analysis of the MAQ data showed a fairly distinct and identifiable pattern of convergent and discriminant validity. The mapping clearly shows that within bounds, the within-each-factor correlations are significantly higher, indicative of convergent validity in contrast to the lower, among-factors correlations indicative of discriminant validity. The four extracted factors were therefore accepted on this basis as valid constructs.

While factor analysis facilitates the interpretation of the extracted factors the descriptive labels attached to each factor is based on the individual researchers judgement of the common theme in the items making up a factor. There is therefore a caveat here that the interpretation of extracted factors may not be the same from researcher to researcher. The 'real' construct could well be something else not quite described by the labels attached.

The four extracted and validated constructs in table 6.6 were then used to refine the hypotheses generated in the study initially, on the attitudes of the students to mathematics in the study population. The statistical tests on the extracted constructs in the MAQ together with hypotheses tested are presented in the next section.

## 6.5 Results of Statistical Tests of Hypotheses on Differences in Attitudes to Mathematics between the CAI and TM groups

In this section the hypotheses generated with regards to the differences in student's attitudes to mathematics between the CAI and TM groups derived from the MAQ data, are presented. Also presented in this section are the results of the Mann Whitney U Test on the generated hypotheses from the MAQ.

### 6.5.1 Hypotheses on Differences in Students' Attitudes to Mathematics Between the CAI and TM groups.

The attitudes of students to mathematics in the two samples under study were investigated in order to identify differences to contextualise their performances in the mathematics pretest and posttest. The hypotheses that follow were derived from the desire to investigate the following questions.

Is there a difference in the attitudes of the CAI and TM students to the following aspects of mathematics?

1. Mathematics is culturally relevant
2. Mathematics is confusing
3. Mathematics is important
4. Mathematics is useful

There were a number of questions that were posed initially at the design stage of the study to investigate student attitudes to mathematics. After the factor analysis these questions were refined and refocussed into the four aspects of mathematics as listed above which the available data was able to address.

The following are the null hypotheses from the four aspects of mathematics.

**Null Hypotheses**

$H_o1$: There is no difference in attitude between the CAI and TM students to the relevance of mathematics to their cultural context

$H_o2$: There is no difference in attitude between the CAI and TM students that mathematics is confusing.

$H_o3$: There is no difference in attitude between the CAI and TM students that mathematics is important.

$H_o4$: There is no difference in attitude between the CAI and TM students that mathematics is useful.

### 6.5.2 Comparing the Attitudes of the CAI and TM Groups Towards Mathematics using the Mann Whitney U Test

The reasons for the use of the Mann Whitney U test in the context of the present study were discussed thoroughly in section 4.11.1 in chapter 4. The Mann Whitney U tests for differences between two independent groups on some measure and is a powerful alternative to the parametric t-test without the accompanying assumptions of the t-test (Siegel and Castellan (1988)). The two groups compared in the Mann Whitney U Test were the CAI group and the TM group, which were established in the foregoing sections as independent groups.

Table 6.7b below shows that all 4 hypotheses were retained i.e. there was no significant difference in attitude to all four aspects of mathematics between the CAI group and the TM group. This conclusion implies that the students performance in the pretest and the posttest is not compounded by any underlying but undetermined attitudinal bias factor introduced into the design of the investigation by the way the tutorial groups were formed. This further implies that any differences detected in the performance of the students on the posttest in particular can be attributed to some other factor such as tutorial method for instance.

***Table 6.7 Mathematics Attitude Differences between CAI and TM Students***

*$H_01$ - 4*: There is no difference in attitude between the CAI and TM students…

**Table 6.7a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| ...to the relevance of mathematics to their cultural context | 1 | 42 | 52.88 | 2221.00 |
| | 2 | 57 | 47.88 | 2729.00 |
| | Total | 99 | | |
| ...that mathematics is confusing | 1 | 42 | 55.65 | 2337.50 |
| | 2 | 57 | 45.83 | 2612.50 |
| | Total | 99 | | |
| ...that mathematics is important | 1 | 42 | 51.40 | 2159.00 |
| | 2 | 57 | 48.96 | 2791.00 |
| | Total | 99 | | |
| ...that mathematics is useful | 1 | 42 | 53.40 | 2243.00 |
| | 2 | 57 | 47.49 | 2707.00 |
| | Total | 99 | | |

**Table 6.7b: Test Statistics**

| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|
| ...to the relevance of mathematics to their cultural context | 1076.000 | 2729.000 | -.858 | .391 |
| ...that mathematics is confusing | 959.500 | 2612.500 | -1.685 | .092 |
| ...that mathematics is important | 1138.000 | 2791.000 | -.425 | .671 |
| ...that mathematics is useful | 1054.000 | 2707.000 | -1.033 | .301 |

a. Grouping Variable: Class Group

## 6.6 Correlational Analyses on Number of Attempts at Mathematics 2 and Performance in the Pretest and the Posttest

The following hypothesis was generated in further efforts to discount all other factors other than instructional mode for differences in performance in the pretest and the posttest. The hypothesis investigated whether there was any correlation between doing Mathematics 2 more than once and performances in the pretest and the posttest. This was a concern because 33 percent of the main study sample had indicated that they were repeating the course mathematics 2 in semester 1 of 2000 (see table 5.1 in chapter 5). A significant difference would imply that performance in the pretest and the posttest was affected by factors other than instructional mode only. In particular the conclusion would be that students repeating the course have a better chance of doing well than those who were doing the course for the first time.

***Table 6.8: Correlation between Number of Attempts at Mathematics 2 and Performance in the Pretest and Posttest***

$H_{01}$: There is no correlation between the number of attempts at Mathematics 2 and performance in the pretest.

$H_{02}$: There is no correlation between the number of attempts at Mathematics 2 and performance in the posttest.

**Table 6.8: Correlations**

| | | | Pretest | Posttest |
|---|---|---|---|---|
| Spearman's rho | Number of times Mathematics 2 attempted | Correlation Coefficient | .157 | -.140 |
| | | Sig. (2-tailed) | .244 | .234 |
| | | N | 57 | 74 |

Both $H_{01}$ and $H_{02}$ were retained i.e. there is no correlation between number of attempts at mathematics 2 and performance in either the pretest or the posttest. In addition to discounting repetition of the course as a factor affecting performance this result also touches on another important issue. Given this result the question could well be asked as to whether repeating the course benefits the students or whether it is a waste of their time. This question is important in the light of many students being allowed to do the course repeatedly over a number of semesters to achieve a pass if they don't achieve that in the first attempt.

## 6.7 Validity Considerations for the Pretest and the Posttest

The validity of the pretest and the posttest are argued and established in exactly the same manner as it was argued and established in the pilot study. It is argued and established on the basis of a content analysis of mathematics 2 by comparing the results from the pretest and the posttest with the results from the Final Examination at the end of semester 1, 2000 (semester 2, 1999 for the pilot study). Table 6.9 and 6.10 tabulate the results of the correlation analyses, between the pretest and the final examination, and between the posttest and the final examination respectively.

**Table 6.9: Correlations**

| | | | FinalExam |
|---|---|---|---|
| Spearman's rho | Pretest | Correlation Coefficient | .358* |
| | | Sig. (2-tailed) | .012 |
| | | N | 49 |

*. Correlation is significant at the .05 level (2-tailed).

**Table 6.10: Correlations**

| | | | FinalExam |
|---|---|---|---|
| Spearman's rho | Posttest | Correlation Coefficient | .804** |
| | | Sig. (2-tailed) | .000 |
| | | N | 80 |

**. Correlation is significant at the .01 level (2-tailed).

It is important to note here that the researcher did not set the final examination. While the researcher wrote the pretest/posttest, the IDCF mathematics coordinator independently wrote and set the final examination. The correlation between the pretest and the final examination and between the posttest and the final examination were both significant at the .02 level. This suggests that the two tests were testing in the same domain of objectives. That the pretest and the posttest would test in the same domain of objectives as the final examination was obviously consistent with the essential purpose of the pretest and the posttest, and thus indicates face validity in both tests. It was not possible to conduct any other kind of validity test on the pretest and the posttest.

The validity of the performance test scale was therefore accepted on the basis of this strong correlation between the pretest and the final examination and between the posttest and the final examination.

## 6.8 Reliability Considerations for the Pretest and the Posttest

The reliability of the posttest in the pilot study was argued on the basis of its content validity, given that a valid test is always reliable. On this basis a case was made for the reliability of the posttest in the pilot study due to its established validity, within the context of the course objectives of mathematics 2 as indicated by the high and significant correlation between the posttest and the final examination.

It was noted in the pilot study that due to a lack of supervisory advice, given that the fieldwork was conducted away from the 'home' institution, important information such as students' performance on individual items in both the pretest and the posttest were not noted. Unfortunately it was not possible to recover that information retrospectively upon the realisation that the information was important because, in the case of the posttest at least, the papers had been returned to the students. The posttest doubled as the mid-semester test for semester 1, 2000 which is a part of the continuous assessment in the course mathematics 2, hence the need to return the papers to the students for revision purposes.

In the main study, reliability for the performance test was established using the test-retest method because the same test was given to the same group of students first as the pretest and then as the posttest. Using this method the two sets of scores were correlated using the Spearman rank correlation coefficient which was significant at the 0.01 significance level as shown in table 6.11 below.

**Table 6.11: Correlations**

| | | | Posttest |
|---|---|---|---|
| Spearman's rho | Pretest | Correlation Coefficient | .528** |
| | | Sig. (2-tailed) | .000 |
| | | N | 51 |

**. Correlation is significant at the .01 level (2-tailed).

Table 6.11 indicates that there is a high correlation between the pretest and the posttest, strongly implying that the performance test was consistent under the test/re-test conditions for reliability. A reliable test is one that yields stable or *reliable* results under varying circumstances and the performance is also repeatable and the pretest and posttest correlation results in table 6.11 show this out clearly.

The statistical tests of hypotheses performed on the pretest and posttest data in the main study are presented in the next section (6.9). These statistical tests are performed on the pretest, posttest and final examination data, based on the established reliability and validity of the tests within the context of the mathematics 2 course objectives.

## 6.9 Noting Differences in Level of Competence in Mathematics 2 between the Pretest and the Posttest

This Hypothesis on students' performances in the achievement test investigated whether there was a significant improvement in level of competence and achievement in mathematics 2 between the sitting of the pretest and the sitting of the posttest some 7 weeks later. This v as an important consideration in determining whether the achievements of the students is more a reflection of a poorly designed course or otherwise. If the students' performances in mathematics 2 had not improved at all over a 7-week period regardless of mode of instruction, it would be difficult to avoid the conclusion that the mathematics 2 course is problematic because of poor design. That mathematics 2 is not an appropriate vehicle with which to collect data as intended in the present study.

$H_0$: There is no difference in the students' level of competence in mathematics 2 concepts between the results in the pretest and the results in the posttest.

The Wilcoxon Signed Rank Test was used to test the null hypothesis, $H_0$, because the pretest and the posttest were the same and the hypothesis only tests for differences in performance on the achievement test between time 1 and time 2. Time 1 was when the pretest was sat and time 2 was when the posttest was sat.

Table 6.12b shows that the null hypothesis, $H_0$, is significant, thus rejecting the null hypothesis, significant learning did occur in the 7 weeks of tutorials between the sitting of the pretest and the sitting of the posttest. This implies that while the mathematics 2 course may not be perfect it is possible to conduct the core investigation of the present study using mathematics 2 as the domain. The core investigation was of course noting differences in performance in mathematics 2 as a function of instructional mode.

*Table 6.12a: **Wilcoxon Signed Rank Test Testing Differences in Performances in the Pretest and the posttest - Ranks***

**Ranks**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST - Pretest | Negative Ranks | 3[a] | 9.17 | 27.50 |
| | Positive Ranks | 47[b] | 26.54 | 1247.50 |
| | Ties | 1[c] | | |
| | Total | 51 | | |

a. POSTTEST < Pretest

b. POSTTEST > Pretest

c. Pretest = POSTTEST

*Table 6.12b: **Wilcoxon Signed Rank Test Testing Differences in Performances in the Pretest and the posttest – Test Statistic***

**Test Statistics[b]**

| | POSTTEST - Pretest |
|---|---|
| Z | -5.897[a] |
| Asymp. Sig. (2-tailed) | .000 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

## 6.10 Results of Statistical Tests of Hypotheses on Differences in Performance in the Pretest, Posttest and the Final Examination between the CAI and TM groups

Investigation questions are posed for each of the three tests (pretest, posttest and final examination). The investigation questions are then used to generate hypotheses that are tested comparing performances between the CAI group and the TM group in the tests using the Mann Whitney U test.

For the pretest there is only one investigation question and a hypothesis generated from that question. Attendance levels at CAI tutorials, by the CAI group, was not an important factor in the analysis of comparative performances in the pretest because the students completed this test prior to the commencement of tutorials.

In comparison to the above there were 6 investigation questions each in the posttest and the final examination, based on attendance levels at CAI tutorial sessions by the CAI group. Each investigation question in the posttest and the final examination is associated with an appropriate hypothesis.

The results of the tests of these hypotheses are presented in the following sections and subsections under appropriate headings.

### 6.10.1 A Comparison of the CAI and TM Students' Performances in the Pretest

**Investigation Question:**

Is there a significant difference in performance between the CAI group and the TM group in the pretest?

**Hypothesis:**

$H_o$ : There is no difference in performance on the pretest between the CAI Group and the TM Group

Table 6.13a: Ranks

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Pretest | 1 | 35 | 34.23 | 1198.00 |
| | 2 | 29 | 30.41 | 882.00 |
| | Total | 64 | | |

Table 6.13 b: Test Statistics[a]

| | Pretest |
|---|---|
| Mann-Whitney U | 447.000 |
| Wilcoxon W | 882.000 |
| Z | -.819 |
| Asymp. Sig. (2-tailed) | .413 |

a. Grouping Variable: Class Group

$H_0$ is retained i.e. there is no difference in performance between the CAI group and the TM group on the pretest. This is an expected result as it was established from the MAQ data analysis earlier in this chapter that the CAI and TM groups were independent, statistically unbiased groups.

The students sat the pretest before any tutorials in mathematics 2 were conducted, as noted in section 5.5.3 in chapter 5 on data collection procedures. The analysis of the data just once at the end of the 7-week period of instructions was therefore considered appropriate and sufficient in contrast to that in the posttest and the final examination, where the multiple analyses (situations) reflect the different levels of attendance at tutorials.

Basically the performance on the pretest went very much according to expectations that there would not be any significant difference in performance between the CAI group and the TM group.

### 6.10.2 A Comparison of the CAI and TM Students' Performances in the Posttest

In contrast to the pretest, which was a once only analysis for each of the two groups as they appeared at the end of the seven weeks of observed tutorials, the analysis of the posttest was based on the number of attendance at tutorial sessions by the CAI students. Each different level of attendance at tutorial sessions by the CAI students is depicted as a "situation". There were a total of six situations with "situation 1" representing at least one attendance at a tutorial session, and so on until situation 6 which represented attendance at six or seven tutorial sessions. There were only seven tutorials in total. Tables 6.14 – 6.19 below show the results of the Mann Whitney U test performed on the posttest, by number of attendance at CAI tutorials by the CAI group.

The investigation question and hypothesis for each situation therefore reflects the attendance level at CAI tutorials by the CAI students.

The researcher makes the note here in advance of the analysis of the six situations for the posttest that none of the resulting P-Values reached significance. The point of the exercise of tabulating the results though becomes clearer in section 6.10.3 following the discussion on the trend in the P-Values as illustrated quite clearly in figure 6.[illegible].

#### 6.10.2.1 Situation 1

Situation 1 compares the performance of CAI students who attended at least one tutorial session against TM Students.

**Investigation Question 1:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least one session?

$H_o 1$ : There is no difference in performance on the posttest between the CAI Group and the TM Group under the conditions of at least one attendance at CAI tutorial sessions by the CAI group.

**Table 6.14a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 45 | 45.53 | 2049.00 |
| | TM | 44 | 44.45 | 1956.00 |
| | Total | 89 | | |

**Table 6.14b: Test Statistics[a]**

| | POSTTEST |
|---|---|
| Mann-Whitney U | 966.000 |
| Wilcoxon W | 1956.000 |
| Z | -.197 |
| Asymp. Sig. (2-tailed) | .844 |

a. Grouping Variable: Class Group

Table 6.14b shows that $H_o1$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least one attendance at CAI tutorial sessions by the CAI group.

#### 6.10.2.2 Situation 2

Situation 2 compared the performance of CAI students who attended at least two CAI tutorial sessions against TM Students.

**Investigation Question 2:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least two sessions?

$H_o2$ : There is no difference in performance on the posttest between the CAI Group and the TM Group under the conditions of at least two attendances at CAI tutorial sessions by the CAI group.

**Table 6.15a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 42 | 46.56 | 1955.50 |
| | TM | 47 | 43.61 | 2049.50 |
| | Total | 89 | | |

**Table 6.15b: Test Statistics[a]**

| | POSTTEST |
|---|---|
| Mann-Whitney U | 921.500 |
| Wilcoxon W | 2049.500 |
| Z | -.539 |
| Asymp. Sig. (2-tailed) | .590 |

a. Grouping Variable: Class Group

Table 6.15b shows that $H_o2$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least two attendances at CAI tutorial sessions by the CAI group.

### 6.10.2.3 Situation 3

Situation 3 compared the performances of CAI students who attended at least three CAI tutorial sessions against TM Students.

**Investigation Question 3:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least three sessions?

$H_o 3$ : There is no difference in performance on the posttest between the CAI Group and the TM Group under the conditions of at least three attendances at CAI tutorial sessions by the CAI group.

**Table 6.16a:** **Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Posttest | CAI | 39 | 47.21 | 1841.00 |
| | TM | 50 | 43.28 | 2164.00 |
| | Total | 89 | | |

**Table 6.16b:** **Test Statistics**[a]

| | POSTTEST |
|---|---|
| Mann-Whitney U | 889.000 |
| Wilcoxon W | 2164.000 |
| Z | -.712 |
| Asymp. Sig. (2-tailed) | .476 |

a. Grouping Variable: Class Group

Table 6.16b shows that $H_o 3$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least three attendances at CAI tutorial sessions by the CAI group.

### 6.10.2.4 Situation 4

Situation 4 compared the performances of CAI students who attended at least four CAI tutorial sessions against TM Students.

**Investigation Question 4:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least four sessions?

$H_o4$ : There is no difference in performance on the posttest between the CAI Group and the TM Group under the conditions of at least four attendances at CAI tutorial sessions by the CAI group.

**Table 6.17a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 36 | 48.15 | 1733.50 |
| | TM | 53 | 42.86 | 2271.50 |
| | Total | 89 | | |

**Table 6.17b: Test Statistics**[a]

| | POSTTEST |
|---|---|
| Mann-Whitney U | 840.500 |
| Wilcoxon W | 2271.500 |
| Z | -.951 |
| Asymp. Sig. (2-tailed) | .342 |

a. Grouping Variable: Class Group

Table 6.17b shows that $H_o4$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least four attendances at CAI tutorial sessions by the CAI group.

### 6.10.2.5 Situation 5

Situation 5 compared the performances of CAI students who attended at least five CAI tutorial sessions against TM Students.

**Investigation Question 5:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least five sessions?

$H_o5$ : There is no difference in performance on the posttest between the

CAI Group and the TM Group under the conditions of at least five attendances at CAI tutorial sessions by the CAI group.

**Table 6.18a:** **Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 23 | 52.57 | 1209.00 |
| | TM | 66 | 42.36 | 2796.00 |
| | Total | 89 | | |

**Table 6.18b:** **Test Statistics**[a]

| | POSTTEST |
|---|---|
| Mann-Whitney U | 585.000 |
| Wilcoxon W | 2796.000 |
| Z | -1.634 |
| Asymp. Sig. (2-tailed) | .102 |

a. Grouping Variable: Class Group

Table 6.18b shows that $H_o5$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least five attendances at CAI tutorial sessions by the CAI group.

### 6.10.2.6 Situation 6

Situation 6 compared the performances of CAI students who attended either six or seven CAI tutorial sessions with TM Students. There were only seven tutorial sessions organised in the study. The sample of students who attended six or seven CAI tutorial sessions was getting rather small hence the decision not to have a seventh "situation".

**Investigation Question 6:**

Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least six or seven sessions?

$H_o5$ : There is no difference in performance on the posttest between the CAI Group and the TM Group under the conditions of at least six or seven attendances at CAI tutorial sessions by the CAI group.

**Table 6.19a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 15 | 51.83 | 777.50 |
| | TM | 74 | 43.61 | 3227.50 |
| | Total | 89 | | |

**Table 6.19b: Test Statistics[a]**

| | POSTTEST |
|---|---|
| Mann-Whitney U | 452.500 |
| Wilcoxon W | 3227.500 |
| Z | -1.125 |
| Asymp. Sig. (2-tailed) | .260 |

a. Grouping Variable: Class Group

Table 6.19b shows that $H_o6$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the posttest, under the conditions of at least six or seven attendances at CAI tutorial sessions by the CAI group.

The next section sets out and explains the reasons why the researcher considered it important to tabulate the six results, although none of the P-Values reached significance.

### 6.10.3 Noting the Trend in P-values from the Analysis of the Results in the Posttest

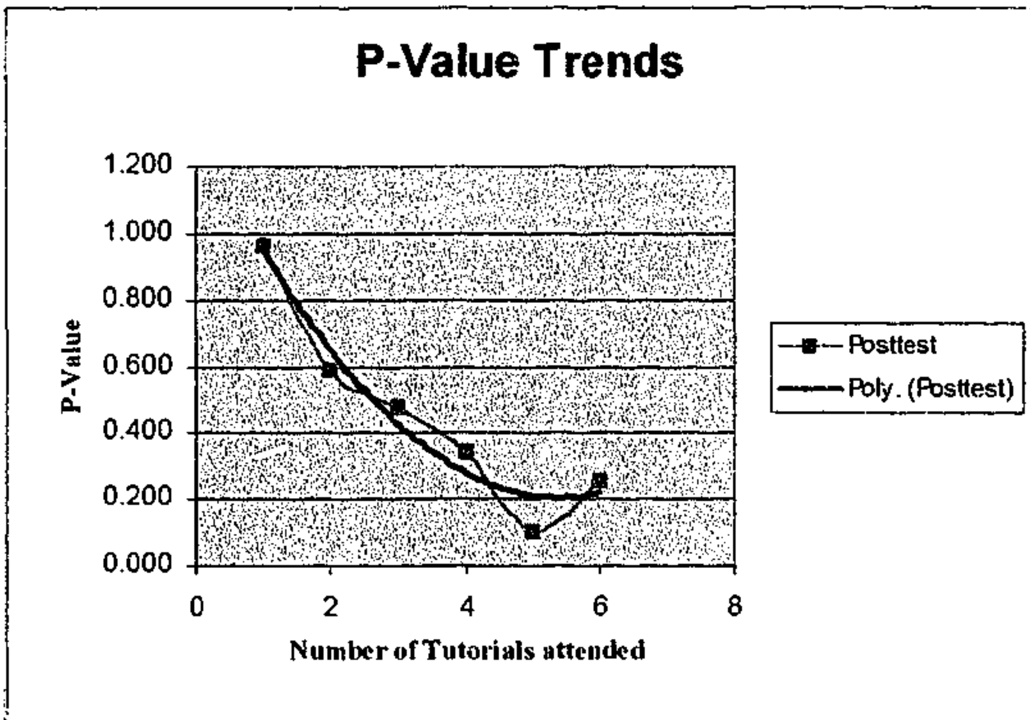
In all cases (situations 1 to 6) the P-values do not reach significance but the interesting observation was the trend in the way the P-Values varied. It was noted quite by accident that there was a trend to how the P-Values varied from situation 1 to situation 6. In order to portray the trend more clearly the six attendance levels were plotted against the P-values obtained in the analysis under the six situations in a graph using the Excel Spreadsheet. A trend line was then drawn from the plotted points to highlight any general trends that might be present in the way the P-Values varied. The trend line is automatically generated based on the plotted points by the Excel Spreadsheet.

Table 6.20 is a tabulation of all the P-Values obtained in each of the six situations in sections 6.10.2.1 to 6.10.2.6. The graph below (figure 6.1) is the resulting graph from table 6.20 and it shows a trend very clearly.

***Table 6.20: Attendance Levels and P-Values***

| | Posttest |
|---|---|
| **Attendance** | **P-Value** |
| At least 1 | 0.967 |
| At least 2 | 0.590 |
| At least 3 | 0.476 |
| At least 4 | 0.342 |
| At least 5 | 0.102 |
| At least 6 | 0.260 |

***Figure 6.1: Gr aphical Demonstration of the Trend in P-Values in the Comparative performances of the CAI and TM Tutorial Groups in the Posttest by Tutorial Attendance of the CAI Group***




From figure 6.1 it is quite clear that there is a trend to how the P-Values varied with the number of attendances at CAI tutorial sessions by the CAI group. Although the difference in performances between the CAI group and the TM group were not significant even with different attendance levels it appears that there was a trend in how the P-Values approached significance as attendance at CAI tutorial sessions by the CAI group increased. It appears that the P-values definitely approached significance as attendance at CAI tutorials by the CAI group increased although there is a seeming trend reversal at the end for situation 6. A possible reason for the trend reversal in situation 6 could be the rather small sample size of the sample of students who attended six or all seven tutorials.

Following the highlighting of the trend in figure 6.1 the following question begs an answer. Would the differences in performance between the CAI and the TM groups be significant if the computer-based CAI tutorial sessions had continued beyond just seven weeks and the sample of students attending more tutorials did not shrink to a very small group? The possible answers to this questions and implications will be explored and discussed in chapter 7.

There is of course the possibility that this noted trend was quite accidental and is therefore not a significant phenomenon. But the results obtained in the analysis of the comparative performances of the two groups in the final examination somewhat supports the view that the noted trend in P-Values is significant within the context of the present study.

### 6.10.4 Comparison of the CAI and TM students' Performances in the Final Examination

The parallel analysis to the posttest, regarding the performances of the two groups in the final examination, is presented in this section and the following sub-sections. The results include an analysis similar to that in table 6.20 and figure 6.1 of the parallel trend in the variation of the P-Values on the performances of the two groups in the final examination, based on levels of attendance at CAI tutorials by the CAI group. This analysis is deliberately placed side by the side in the following sub-sections with the posttest analysis, which has already been presented in the previous section to contrast the performances in the two tests. The resulting graph in figure 6.2 shows the variation in P-Values on the performances of the two groups in the posttest and the final examination side by side for comparison.

#### 6.10.4.1 Situation 1

Situation 1 compared the performance of CAI students in the final examination who attended at least one CAI tutorial session against TM Students.

**Investigation Question 1:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least one session?

$H_o 1$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least one attendance at CAI tutorial sessions by the CAI group.

**Table 6.21a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 48 | 47.39 | 2274.50 |
| | TM | 46 | 47.62 | 2190.50 |
| | Total | 94 | | |
| FINALEX | CAI | 42 | 43.75 | 1837.50 |
| | TM | 44 | 43.26 | 1903.50 |
| | Total | 86 | | |

**Table 6.21b: Test Statistics**[a]

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 1098.500 | 913.500 |
| Wilcoxon W | 2274.500 | 1903.500 |
| Z | -.042 | -.091 |
| Asymp. Sig. (2-tailed) | .967 | .928 |

a. Grouping Variable: Class Group

Table 6.21b shows that $H_o 1$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least one attendance at CAI tutorial sessions by the CAI group.

### 6.10.4.2 Situation 2

Situation 2 compared the performance of CAI students in the final examination who attended at least two CAI tutorial sessions against TM Students.

**Investigation Question 2:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least two sessions?

$H_o 2$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least two attendances at CAI tutorial sessions by the CAI group.

**Table 6.22a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 42 | 46.56 | 1955.50 |
| | TM | 47 | 43.61 | 2049.50 |
| | Total | 89 | | |
| FINALEX | CAI | 38 | 45.79 | 1740.00 |
| | TM | 48 | 41.69 | 2001.00 |
| | Total | 86 | | |

**Table 6.22b: Test Statistics**

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 921.500 | 825.000 |
| Wilcoxon W | 2049.500 | 2001.000 |
| Z | -.539 | -.757 |
| Asymp. Sig. (2-tailed) | .590 | .449 |

a. Grouping Variable: Class Group

Table 6.22b shows that $H_o 2$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least two attendances at CAI tutorial sessions by the CAI group.

### 6.10.4.3 Situation 3

Situation 3 compared the performances of CAI students in the final examination who attended at least three CAI tutorial sessions against TM Students.

**Investigation Question 3:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least three sessions?

$H_o3$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least three attendances at CAI tutorial sessions by the CAI group.

**Table 6.23a:** **Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 39 | 47.21 | 1841.00 |
| | TM | 50 | 43.28 | 2164.00 |
| | Total | 89 | | |
| FINALEX | CAI | 35 | 48.20 | 1687.00 |
| | TM | 51 | 40.27 | 2054.00 |
| | Total | 86 | | |

**Table 6.23b:** **Test Statistics**

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 889.000 | 728.000 |
| Wilcoxon W | 2164.000 | 2054.000 |
| Z | -.712 | -1.447 |
| Asymp. Sig. (2-tailed) | .476 | .148 |

a. Grouping Variable: Class Group

Table 6.23b shows that $H_o3$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least three attendances at CAI tutorial sessions by the CAI group.

### 6.10.4.4 Situation 4

Situation 4 compared the performances of CAI students in the final examination who attended at least four CAI tutorial sessions against TM Students.

**Investigation Question 4:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least four sessions?

$H_o4$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least four attendances at CAI tutorial sessions by the CAI group.

**Table 6.24a:** **Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 36 | 48.15 | 1733.50 |
| | TM | 53 | 42.86 | 2271.50 |
| | Total | 89 | | |
| FINALEX | CAI | 32 | 48.75 | 1560.00 |
| | TM | 54 | 40.39 | 2181.00 |
| | Total | 86 | | |

**Table 6.24b:** **Test Statistics**

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 840.500 | 696.000 |
| Wilcoxon W | 2271.500 | 2181.000 |
| Z | -.951 | -1.502 |
| Asymp. Sig. (2-tailed) | .342 | .133 |

a. Grouping Variable: Class Group

Table 6.24b shows that $H_o4$ is retained, i.e. there is no difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least four attendances at CAI tutorial sessions by the CAI group.

### 6.10.4.5 Situation 5

Situation 5 compared the performances of CAI students in the final examination who attended at least five CAI tutorial sessions against TM Students.

**Investigation Question 5:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least five sessions?

$H_0 5$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least five attendances at CAI tutorial sessions by the CAI group.

**Table 6.25a: Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 23 | 52.57 | 1209.00 |
| | TM | 66 | 42.36 | 2796.00 |
| | Total | 89 | | |
| FINALEX | CAI | 20 | 57.90 | 1158.00 |
| | TM | 66 | 39.14 | 2583.00 |
| | Total | 86 | | |

**Table 6.25b: Test Statistics**

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 585.000 | 372.000 |
| Wilcoxon W | 2796.000 | 2583.000 |
| Z | -1.634 | -2.945 |
| Asymp. Sig. (2-tailed) | .102 | .003 |

a. Grouping Variable: Class Group

Table 6.25b shows that $H_o5$ is rejected, i.e. there is a significant difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least five attendances at CAI tutorial sessions by the CAI group. The difference is significant at the 0.01 level of significance.

### 6.10.4.6 Situation 6

Situation 6 compared the performances of CAI students in the final examination who attended either six or seven CAI tutorial sessions with TM Students. It is re-stated here again that there were only seven tutorial sessions organised in the main study. The sample of students who attended six or seven CAI tutorial sessions was getting rather small hence the decision not to have a seventh "situation".

**Investigation Question 6:**

Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least six or seven sessions?

$H_o6$ : There is no difference in performance on the final examination between the CAI Group and the TM Group under the conditions of at least six or seven attendances at CAI tutorial sessions by the CAI group.

**Table 6.26a:** **Ranks**

| | Class Group | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| POSTTEST | CAI | 15 | 51.83 | 777.50 |
| | TM | 74 | 43.61 | 3227.50 |
| | Total | 89 | | |
| FINALEX | CAI | 14 | 59.79 | 837.00 |
| | TM | 72 | 40.33 | 2904.00 |
| | Total | 86 | | |

**Table 6.26b:** **Test Statistics**

| | POSTTEST | FINALEX |
|---|---|---|
| Mann-Whitney U | 452.500 | 276.000 |
| Wilcoxon W | 3227.500 | 2904.000 |
| Z | -1.125 | -2.668 |
| Asymp. Sig. (2-tailed) | .260 | .008 |

a. Grouping Variable: Class Group

Table 6.26b shows that $H_o6$ is rejected, i.e. there is a significant difference in performance between the CAI group and the TM group on the final examination, under the conditions of at least six or seven attendances at CAI tutorial sessions by the CAI group. The difference is significant at the 0.01 level of significance.

Tables 6.21b to 6.26b shows that the P-Value reached significance in the final examination as the number of tutorials increased in comparison to that in the posttest, which tended towards significance without reaching significance. Significance was reached when attendance at CAI tutorial sessions by the CAI group was at least 5 attendances.

### 6.10.5 Noting the Trend in P-values from the Analysis of the Results in the Final Examination

Table 6.27 below is a tabulation of the P-Values in the six situations in the analysis of the performances of the two groups (CAI and TM) in the final examinations with the P-Values from the analysis of the posttest placed alongside for comparison.

*Table 6.27 Attendance Levels and P-Values*

| | Posttest | Final Ex |
|---|---|---|
| Attendance | P-Value | P-Value |
| At least 1 | 0.967 | 0.928 |
| At least 2 | 0.590 | 0.449 |
| At least 3 | 0.476 | 0.148 |
| At least 4 | 0.342 | 0.133 |
| At least 5 | 0.102 | 0.003 |
| At least 6 | 0.260 | 0.008 |

*Figure 6.2: Graphical Demonstration of the Trend in P-Values in the Comparative performances of the CAI and TM Tutorial Groups in the final examination by Tutorial Attendance of the CAI Group*

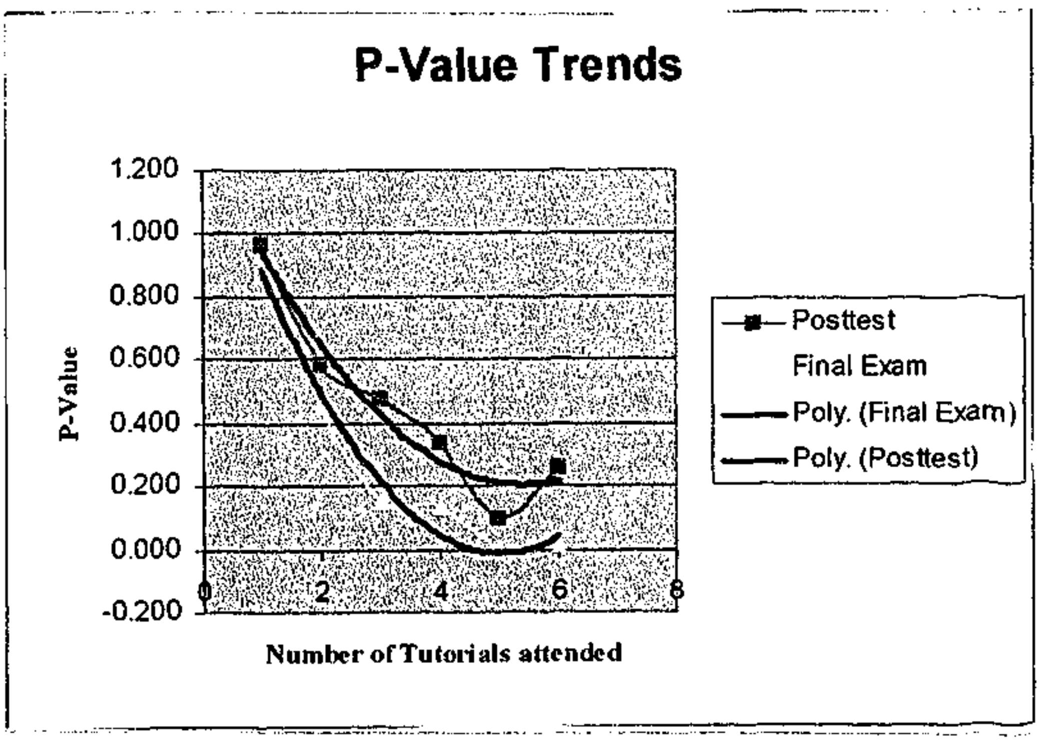


Figure 6.2 confirms the trend observed in figure 6.1 on the comparative performances of the CAI and TM groups on the posttest. As noted from table 6.27, the P-Values for the comparative performances in the posttest did not reach significance with increasing levels of attendance although there was a noticeable trend towards significance. In comparison, the P-Values for the comparative performances in the final examination did reach significance with increasing levels of attendance at CAI tutorials by the CAI group.

The noted trends, in the P-Values of the comparative performances of the two groups in the posttest, could have been entirely accidental. However, the parallel trend in the results of the analysis of the comparative performances of the two groups in the final examination, somewhat discounts that possibility.

As noted in section 6.7 on the validity considerations of the posttest, there was a high correlation between the posttest and the final examination strongly suggesting that the two tests were testing in the same domain of objectives. This point assumes such importance when considered in connection with the trends in P-Values noted above because the main difference between the two tests would then simply be the time factor. The posttest was applied almost immediately at the end of the seven weeks of tutorials whereas the final examination was applied some seven more weeks after the end of the seven weeks of research-related tutorials. This strongly suggests that longer-term retention of mathematical concepts learned using the computer-based tutorials is significantly enhanced.

The results also further suggest that in the longer-term, computer-based tutorials in mathematics and in particular mathematics 2 are highly beneficial and at the very least as effective as the current practices in mathematics tutoring in IDCE. Further discussions of the results are enjoined in chapter 6 on the conclusions and the discussions of the results in the main study.

## 6.11 Summary

This chapter presented the results of the analysis of the instruments used in the main study of the present study. Six instruments were used for the data collection for this study these were the MAQ, CSQ1, CSQ2, pretest, Posttest and the final examination. Although only five instruments were specifically designed and prepared for the present study, six instruments in total, including the final examination, were actually use for data collection and analysis in the main study.

The study was conducted in the mathematics 2-course domain as in the pilot study and was facilitated by the computer-based Lebo Mathematics 2 software, which was specifically designed and developed by the researcher for the present study. Whereas Lebo 1.0 was used in the pilot study, Lebo 1.5, an upgrade version of Lebo 1.0, was used in the main study.

The period of research-related tutorials was seven weeks compared to only four weeks for the pilot study. In general students in the sample population were found to have generally very positive attitudes to mathematics as shown by the responses to the Mathematics Attitudes Questionnaire (MAQ). CAI students were also found to have generally positive attitudes to computers, as noted from the responses to the CSQ1 and CSQ2 questionnaires.

In effecting the comparison of performances on the posttest and the final examination between the CAI group and the TM group, the CAI students were grouped according to attendance levels at CAI tutorials. Each of the six resulting groups (situations) was then compared to the TM group and the P-Value noted. A pattern of variation was noted when attendance levels as defined by the six situations were plotted against P-values in both the posttest and the final examination results. While the P-Values in the six situations tended towards significance without reaching significance in the posttest, the P-Values in the final examination did actually reach significance with increasing attendance levels at CAI tutorials by the CAI group.

This led to the conclusion that CAI is effective as a mode of instruction in the distance education situation in Papua New Guinea among matriculation students. There is a strong suggestion from the results that over the period of 14 weeks (one semester), which is the current duration of the course, computer-based mathematics students may even out-perform students who do the course in the usual (TM) way. There is also the suggestion that students taught via the computer-based method may even experience better retention of learned mathematics concepts in the longer term than the students taught via the TM method.

In the pilot study, in contrast to the above, no significant difference was found in performance between the CAI students and the TM students in the posttest and the final examination. The difference between the pilot study and the main study was the duration of the study. Whereas the pilot study was conducted over just four weeks, the main study was conducted over 7 weeks.

At the very least the results of the present study show that the CAI method is as effective as the TM method in mediating instruction in mathematics. It was also found that there is a significant link between attitudes to mathematics and performance in the posttest, implying that students with more positive attitudes to mathematics perform better than students with less positive attitudes to mathematics.

Discussion of the findings, implications, recommendation and conclusion of the present study is presented in the next chapter (chapter 7).

# Chapter 7: Discussion and Conclusions

## 7.1 Introduction

In this chapter the results from the main study presented in chapter 6 are discussed.

As is obvious from chapter 6 the investigation was conducted along three interrelated directions. These were students' attitudes to mathematics, students' attitudes to computers and students' comparative performances in mathematics achievement tests, as a function of instructional mode. The core investigation was of course students' comparative performances in mathematics performance tests, as a function of mode of instruction. The attitude questionnaires on mathematics and computers were applied solely to contextualise the students' performance in the achievement tests.

The three interrelated directions or prongs of the investigation all focussed on understanding the core issue of whether CAI is effective compared to traditional modes of instruction at the Institute of Distance and Continuing Education (IDCE). The investigation was conducted in the context of the research questions as posed at the start of the study and noted in chapter 1, and restated below in sections 7.4 and 7.5. The research questions are grouped according to the three prongs of the investigation.

In the following discussions the findings of the present study are related to results from other relevant studies, previously noted in chapter 3. This is followed by a discussion of the implications for the implementation of a computer-based instruction and learning system in PNG in a distance education setting.

## 7.2 A Re-Statement of the Research Problem Context

UPNG distance education courses administered by IDCE are entirely text-based at present, supplemented with limited face-to-face tutorials where possible. Since the inception of distance education at UPNG in 1975 there has been no change in the mode of instruction. The normal structure of the tuition system in IDCE courses is course booklets with pre-determined objectives and outcomes plus 2 hours per week of face-to-face tutorial per student per course. The face-to-face tutorial sessions are not compulsory and are offered only where numbers of students make it economically feasible to provide them. Many students in the university centres and sub-centres, many of which are in very remote locations, often miss out on any form of face-to-face tutorial assistance. Often these students in remote areas take an inordinately long time to complete a course. They keep enrolling in the same course from semester to semester over a number of years because they don't have the necessary support systems such as tutorial assistance to successfully complete the course. Where the student eventually does complete the course, questions remain on whether the student's learning is equivalent to that of other students who had benefited from a more varied tutorial experience than simply text-based.

The reasons for non-completion over a period of time are varied. Some of the reasons were visited in earlier discussions. Part of the problem as discussed in chapter 2, lies with the prevailing perception in PNG that distance education is inferior to traditional education. As noted in previous chapters, traditional education is often equated with a face-to-face oral presentation situation. This means distance education as a mode of learning for PNG students, and text are problematic. Papua New Guineans, in common with people from other traditional societies, may be more collectivistic (group-oriented) than westerners (Holtzman, 1975; Perraton, 1979) in their approach to learning, while the ideology behind distance education is often focussed on towards an individualistic approach. The predominance of text in PNG distance education may also be anathema to PNG students (Guy, 1990) whose early childhood learning and their entire cultural education is often orally derived. In this context, computer-based teaching and learning as in CAI can be designed to employ the sensory perceptions of sight and sound of the PNG distance learner more effectively than text-based distance education. CAI is interactive and can be designed to employ these senses more effectively to provide the learner with a more experiential basis for learning.

Literature abounds with reports of studies on the efficacy of CAI compared to traditional methods of instruction, going back to the late sixties. A look at some meta-analyses of studies on the efficacy of CAI (e.g. Khalili and Shashaani (1994);

Kulik, Bangert and Williams (1983); Fletcher-Flinn and Gravatt (1995) to note just a few), seems to suggest the superiority of CAI over traditional methods of instruction. This well-documented effectiveness of CAI in mediating instructions can be utilised to supplement and enhance current practices in distance learning in PNG.

There is some anecdotal evidence, although not backed by substantive data, that UPNG distance education students prefer face-to-face tutorials, where it is feasible to attend them, than text-only tuition. There is a sense, noted by some (e.g. Markowitz (1993)), that amongst PNG students, learning that is exclusively text-based, as in the present correspondence-based distance education, is considered inferior to face-to-face learning situations. More specifically, the lack of human presence in a given learning situation, such as those that prevail in the distance mode of learning, is problematic for PNG students. This view conflicts with the philosophy of distance education as well as with what goes on at present, in distance education in PNG.

The present study therefore specifically responded to the perception that UPNG distance education students need more than just text-based tuition at a distance for effective learning. This problem is partly addressed by the provision of the 2 hours per week face-to-face tutorials. Unfortunately, the face-to-face tutorials have either not been very effective or are not available for many of the IDCE students enrolled in the various distance courses. The response recognises that face-to-face tutorial help for distance students is very limited and often may not even be available or possible due to various logistic reasons. However, with some re-organisation at University Centres, involving the adoption of computer-based learning systems, a near face-to-face instructional situation is possible using computer-based communications facilities. The implications of the findings of the present study for PNG distance education are enormous and are discussed in section 7.9.

CDROM-based CAI, as proposed in the present study, can also provide a more interactive form of tuition than the current texts are doing. As noted in chapter 3, interactivity, which is a particular strength of CAI learning programs is important for effective learning. Many distance education courses in many countries are increasingly being made available online or mediated by some form of computer-based technology such as CD-ROM for instance. The present study in fact uses CD-ROM and CD-ROM-like devices such as zip drives as enabling technologies to facilitate the development of the CAI software used for the investigation.

As briefly set out in chapter 1, the study investigates the efficacy of a computer-based system of instruction (CAI) in providing the supplementary, 2 hours per week, face-to-face instruction in the IDCE matriculation course mathematics 2. Because of the problems noted during the conduct of the study, the results are of limited generalisation to the totality of the UPNG distance education program. However, certain lessons can be learned from the results on how instructional practices can be improved in the distance learning mode at UPNG through the application of a mixed instructional mode that involves CAI, particularly in mathematics.

Moreover the present study is one of the first (if not the first) attempts to investigate the efficacy of computer-based learning systems such as CAI to mediate learning in a distance education context in PNG. As a pioneering study therefore there were inevitably problems in a first-up implementation of a computer-based system of teaching and learning, resulting in the limitations to a broad applicability of the findings. Regardless of the limitations of the present study, it does provide some evidence that the CAI method is indeed effective compared to the current practices in IDCE in the teaching of at least the mathematics courses.

It is obvious from observations from the present situation that text-only instruction is not very effective and questions remain on the efficacy of an exclusively computer-based system of instruction. A mixture of modes of instruction is therefore the best approach to providing instruction to PNG students studying in the distance mode. However, questions on efficacy and efficiency of instruction can only be addressed effectively through further research investigation that goes beyond the present study, which is only a beginning.

The next section briefly summarises how the study was implemented, as a contextual background to the discussions that follow.

## 7.3 A Brief Summary of the Conduct of the Present Study

The pilot study was conducted in the second semester of 1999 and the main study was conducted in the first semester of 2000 at the Main Campus of UPNG. Section 4.5 provides a timetable for the conduct of the present study.

Following the pilot study a decision was made to limit the actual research-related instruction time in the main study to just the first seven weeks of the semester, conveniently concluded by the mid-semester test, which also doubled as the posttest. The pilot study was disrupted by a student boycott of classes at UPNG hence was conducted over just four weeks. Both the pilot study and the main study were conducted exclusively at the main centre of IDCE on the Main Campus of UPNG. This was due to adequate computer resources being available only at the Main Campus of UPNG.

Four CAI tutorial sessions were scheduled each week for the seven weeks of CAI tutorials to allow the CAI students options with their individual timetables. Consequently each tutorial session was conducted on a separate day at various times of the day to cater for the needs and preferences of individual students as well as for the various student groups. Each student was allowed attendance at only one CAI tutorial session per week similar to TM students who were also allowed attendance at only one face-to-face tutorial session per week. Tutorial attendance records were kept only for the CAI students. Each tutorial session for both groups was 2 hours in length with an estimated effective contact time of just over an hour. The researcher was assisted in conducting the CAI tutorials by one other tutor who acted the role of support staff to the researcher.

The research population for the main study was the IDCE student cohort of semester 1, 2000 enrolled in the adult matriculation course mathematics 2. A typical student enrolled in the mathematics 2 course is described in table 5.1 in chapter 5. Between 70 to 80 percent of the students were young adults in the 18-24 year age group, not too long out of school. Just over 80 percent of the students had enrolled in the adult matriculation program after completing grade 10 only but with at least 95 percent having had, at least a grade 10 level of general education. The population was over 70 percent male and about 30 percent had also had some form of tertiary education.

Comprehensive sampling was the sampling method employed in selecting students for the main sample population in that all students enrolling in mathematics 2 in semester 1 of 2000 at the Main Campus of UPNG were included in the study. A total of 131 students enrolled for the course at the beginning of the semester on the Main Campus of UPNG, but only 99 students completed the personal information sheet and the MAQ questionnaire. An attempt was made at random sampling in the creation of the two treatment groups: CAI and TM. The attempt was not entirely successful, as noted in chapter 5. In general, the CAI group changed through students dropping out and not seeing the program to the end of the seven weeks of instruction. In contrast, the TM group changed through the addition of students to the group resulting from students dropping out of the CAI group in the course of the seven-week research period.

The research domain that was selected for this study was the adult matriculation (AM) course, mathematics 2 (27.023), a pre-university level course offered by IDCE. The reader is referred to the full description of the course provided in section 4.2.1.

The computer software used in the main study was Lebo 1.5 – An Interactive Mathematics 2 Project, which was developed and written by the researcher specifically for the present study. The reader is referred to chapter 4 for a detailed description of the development of the CAI software. Only the first five topics out of the 9 topics of mathematics 2 were developed sufficiently for use in the CAI tutorials. The 5 topics developed were designed to take the students from the beginning of the semester through to the mid-semester assessment test (posttest) after 7 weeks of instructional time. The following research instruments were used in the study:

1. Mathematics Attitudes Questionnaire (MAQ)
2. Computer Attitudes Questionnaire (CSQ)
   a) Pre-Computer Experience Questionnaire (CSQ1)

b) Post-Computer Experience Questionnaire (CSQ2)

3. Mathematics Performance Test

a) Pretest

b) Posttest

c) Final Examination in mathematics 2

The instruments are described in detail in section 4.2.3 in chapter 4. The instrument versions used in the main study were slight modifications of the instrument versions used in the pilot study.

This section presented a brief summary of the procedures and instrument used in the present study. The next section presents some general observations of the researcher in the laboratory-based CAI tutorials. The observations in the CAI tutorials are compared to observations in the face-to-face tutorials of which the researcher has had considerable experience.

## 7.4 CAI Laboratory Observations Contrasted to Practice in FTF Tutorials

The researcher observed that students were in all cases, while in the CAI tutorials, very focussed and engaged with the task in working through the CAI-mediated mathematics materials. The high level of student engagement on-task in computer-based learning environments such as that with CAI is consistent with observations in literature noted in chapter 3 (e.g. Ronen and Eliahu (2000)). The questions that CAI students asked in the tutorials on subject matter were also much more focussed in contrast to those in the face-to-face tutorials.

The high level of focus and engagement in CAI-based mathematics tutorials is contrasted with the wait-and-see or wait-for-the-next-instruction-from-the-tutor attitude that often prevails in the face-to-face tutorials which often end up as lectures for lack of student questions. The researcher has often observed from experience teaching mathematics 2 students prior to the present study that students in face-to-face tutorials often do nothing more than just copy notes off the board put up by the tutor in explaining various mathematics concepts.

The researcher suspects that students often engage in note-taking, ignoring or paying scant attention to the verbal discourse because they think that the notes contain more vital information than those in their booklets and that they can study the notes later and learn that way. One gets the impression that the students somehow think that notes on the board contain vital clues that are not in their course booklets that they need to pass tests and exams. Unfortunately there is a fallacy to this view because often the notes don't make sense without the verbal discourse that accompanied the notes during the tutorial. The practice of note taking, particularly in the limited face-to-face tutorials in IDCE, is time wasting because often the tutor is re-explaining examples that are already in their course booklets. There seems to be a compulsion in the students to take notes even when they are repeatedly reminded that sufficient notes are provided in the materials they already have and that they should just watch, listen and follow the explanations. While the students are busy copying notes they already have, they are often not following the verbal explanations provided by the tutor.

The observed prevailing characteristic of the PNG distance education student in a face-to-face classroom is often that of a passive observer trying to absorb knowledge in a sponge-like manner. Very often they lack the confidence to even ask simple, focussed questions in the tutorial situation. It is therefore difficult to know what concepts in mathematics in particular the students are having difficulties with. Because the provision of face-to-face tutorials is limited there is usually insufficient time to help students in the tutorials on an individual basis by going around and noting what they are doing wrong. The limited time available for face-to-face consultation during the tutorials often results in a general lecture-like explanation to the whole tutorial group. Unfortunately this only benefits just one or two of the students more focussed on the particular problem. The rest end up basically copying the explanation in case it is a vital clue, then often they don't even take the time to consult the explanation again.

In contrast to all this in most cases in the CAI laboratory-based tutorials the students, working entirely on their own, were totally engaged on-task and consulted the tutor, who was always present, when they had specific questions to ask. The engagement on-task and total absorption with the CAI tutorials was in stark contrast to what happens in face-to-face mathematics tutorials. The students in the CAI laboratory sessions were observed noting and calculating problems as they worked through the CAI tutorials. Often students were seen calculating with pen and paper problems they had worked through in the CAI lessons as an independent check.

The researcher also found it easier to respond to individual queries and to explain concepts which were already portrayed on the computer screen and on which the students were already very much focussed. The biggest problem that CAI students seem to have in the CAI tutorials was with the operation of the computer, a problem which was dealt with by providing training before the CAI tutorials commenced. The students were also observed to progress fairly quickly through the CAI tutorial materials and many in fact repeated the entire set of CAI tutorial materials a number of times. The speed with which the CAI tutorial materials could be covered could also be an explanation of the phenomenon of dwindling numbers in the CAI tutorials towards the latter part of the tutorial period, noted in the next paragraph.

A phenomenon noted in the CAI tutorials was the dwindling numbers in the latter half of the seven weeks of research-related observations. This problem was addressed in the way the data was analysed in the posttest and the final examination as noted in chapter 6, i.e. by level of attendance at CAI tutorials by CAI students.

There is insufficient information from the present study to make conclusions as to whether this was a negative or a positive comment on the CAI tutorials. It is not possible based on the available data to conclude whether this was a sign of boredom with the CAI tutorials or efficiency of learning. Where the students bored after the initial novelty of the mode of instruction had worn off and just neglecting classes'? Alternatively, did the students feel that the first few tutorials had sufficiently organised their thoughts to the extent that they did not need to attend every session? Could it be that based on the few CAI tutorials they attended they felt confident enough to tackle their study notes in the course booklets without further recourse to attendance at tutorials.

Certainly the speed with which the CAI tutorial materials could be covered could be part of the reason why fewer and fewer students attended the laboratory sessions towards the latter part of the 7-week research tutorial period. Kulik, Kulik and Cohen (1980) noted the compression of instructional time through the application of CAI for instance, from a review of a number of studies that showed CAI as significantly better in facilitating speed of instruction. Further research is required to address these and other related questions. A strong impression from the observations is that the CAI tutorials should be no more than about an hour in length, and again this is related to the speed with which the CAI tutorial materials were covered.

The researcher notes here that this phenomenon of dwindling numbers, towards the latter part of a period of instruction in mathematics courses in IDCE, is not unique to the CAI tutorials. It happens also in TM tutorials. It was noted here specifically because of its potential to complicate the research results of the present study.

The next section discusses the attitude trends noted from the analysis of the MAQ and CSQ questionnaires.

## 7.5 Attitude Trends from the MAQ and CSQ Data

As noted in section 7.1, the approach to the investigations in the present study was three-pronged. First, the students' attitudes to mathematics were investigated to provide a mathematics attitude context for their performances in the mathematics achievement test. A mathematics attitude questionnaire (MAQ) facilitated this investigation. Secondly the students' attitudes to the use of computers and the CAI instruction system in mathematics 2 was investigated. Two computer attitude questionnaires (CSQ1 and CSQ2), designed as pre and post computer-experience questionnaires, facilitated this investigation. Again, as with the survey of the attitudes to mathematics, the intention of the CSQ surveys was to contextualise the students' performances in the mathematics achievement test. Thirdly, the core investigation of the present study, the actual investigation of the students' performances in mathematics, was facilitated through a mathematics achievement test. The achievement test was designed in a pre and post- test format with the results in the pretest and posttest being compared to results in the final examination in mathematics 2.

The following subsections (7.5.1 - 7.5.4) discuss the analysis of the results from the MAQ and CSQ questionnaires, presented together with the appropriate research questions and hypotheses. The discussion of the analysis of performances of the students in the mathematics achievement tests appears in section 7.6.

As noted in chapter 6 in the presentation of the results no hypotheses were generated for the computer attitude questionnaires for reasons already discussed in chapters 4 and 6. The data from the computer attitude questionnaire are considered on the basis of the tendencies shown in the students' responses only, guided entirely by some general questions. These questions which were posed in chapter 1 are re-stated below in section 7.5.3.

### 7.5.1 Mathematics Attitudes Research Questions

The attitudes of UPNG distance education students towards pre-University mathematics provide an attitudinal context to their performances in the achievement tests. The students' attitude to mathematics was canvassed using the MAQ instrument. The responses to the questionnaire were analysed on the basis of the two groups determined by instructional mode.

As noted in chapter 6, after the data from the MAQ were subjected to factor analysis, the questions were somewhat reorganised and reworded to reflect the results of the factor analysis as follows:

7. Do matriculation level students in PNG enrolled via the distance study mode in mathematics, in general, have positive or negative attitudes towards mathematics?
8. Do matriculation level students in PNG enrolled via the distance study mode in mathematics see mathematics as too difficult?
9. Is there a significant difference in attitude between the CAI and TM students to the relevance of mathematics to their cultural context?
10. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is confusing?
11. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is important?

12. Is there a significant difference in attitude between the CAI and TM students to the view that mathematics is useful?

### 7.5.2 Discussion of the Analysis of the MAQ Data

Although the questions and the subsequent hypotheses were framed to investigate whether there was a significant difference in attitudes to mathematics between the CAI and the TM groups, it was possible also to draw some general conclusions on attitudes to mathematics of the study population.

The summary statistics in the pilot study (see table 4.5 in chapter 4 and appendix P4) and the main study (see table 6.1 in chapter 6 and appendix M2b) show that IDCE mathematics students generally have positive attitudes to mathematics. This is a general observation derived from the response patterns as portrayed in table 4.5 in chapter 4 and table 6.1 in chapter 6.

The importance of this observation lies in the fact that by far the majority of the students in the study population did not do well enough in school to continue either to upper secondary or directly into tertiary education. The fact of their enrolment in an IDCE matriculation course is evidence of their generally poor performances in mathematics and English in grade 10.

Mathematics and English, being core subjects in school in PNG, dictate the progress of students into the next level in education. Given the IDCE students' poor performances in mathematics in grade 10 prior to enrolling in IDCE, it is rather interesting to note the degree of positiveness in attitudes to mathematics in the study population. Given their experience in mathematics up to grade 10 they would have been expected to dislike mathematics somewhat. It was noted, for instance, in chapter 6 that students in the study sample do mathematics because they perceive that it is important to their learning regardless of their culturally derived views and other factors.

On the other hand the positive attitudes to mathematics portrayed by students who enrol in matriculation courses through IDCE may not be entirely surprising. Doing courses through the distance mode is not considered an easy option. Thus students enrolling through IDCE are often self-motivated to improve their general education in order to enrol in tertiary level courses. The decidedly positive attitudes of IDCE students to mathematics may therefore be a reflection of this self-motivation. The students may be so highly motivated that even the difficulty of mathematics as a subject is accepted as a challenge to overcome.

The researcher did note in chapter 4 another possibility for the high degree of positiveness. The students could have been responding in what they considered a politically correct manner in a bid to 'please' the researcher. Students may not have wanted to be seen as having negative attitudes to mathematics, regardless of the note to all students that the research data would not be used in any other way except as proposed in the research. The research proposal was also publicised to all students in mathematics 2. Unfortunately, whether this was a problem or not in the present study and the degree to which this was the case could not be determined on the data available.

The analysis of the MAQ data also indicated that students generally found mathematics difficult as shown by their responses to items canvassing attitudes to the difficulty of mathematics. These general observations were consistently noted in both the pilot and the main studies. The view of mathematics as a difficult subject is probably neither a positive nor a negative view of mathematics. It is most likely simply an admission of the fact of the difficulty of mathematics.

Another factor investigated using the MAQ in association with the pretest and the posttest was the association between overall attitudes to mathematics and performance in the achievement test. It is evident from tables 7.1 and 7.2 that the association between overall attitudes to mathematics and performance in the achievement tests was significant in the posttest only. This implies that a positive view of mathematics amongst the distance students is associated with a better performance in the posttest test.

***Table 7.1: Correlation between Overall View of Mathematics and Pretest***

Correlation between overall view of mathematics and pretest

| | | | Pretest |
|---|---|---|---|
| Spearman's rho | Overall view of Mathematics | Correlation Coefficient | .172 |
| | | Sig. (2-tailed) | .192 |
| | | N | 59 |

*Table 7.2: Correlation between Overall View of Mathematics and Posttest*

Correlation between overall view of mathematics and posttest

| | | | Posttest |
|---|---|---|---|
| Spearman's rho | Overall view of Mathematics | Correlation Coefficient | .236* |
| | | Sig. (2-tailed) | .042 |
| | | N | 75 |

*. Correlation is significant at the .05 level (2-tailed).

This finding is similar to findings by Kaeley (1989) in a study of a comparable group of students to the study population of the present study, that IDCE distance students' attitudes to mathematics has a significant relationship with performance. Kaeley's study investigated students doing a course, which was the forerunner of mathematics 2.

Research questions 3, 4, 5 and 6 were investigated through hypotheses generated for each of the questions. The hypotheses comparing differences in attitudes to various aspects of mathematics between the two study groups showed that there were no significant differences in attitude between the CAI group and the TM group. The test of hypotheses for differences in attitude, between the two groups, was important in order to discount any bias in the selection of the two groups, given that random selection, although attempted, was not altogether successful. Although on the question of random selection, a meta-analysis by Fletcher-Flinn and Gravatt (1995) on 120 studies comparing CAI to TM noted that random selection did not matter at all in many of the studies.

The conclusion therefore that there were no differences in attitudes to the various aspects of mathematics between the two groups is crucial in establishing the validity of the comparison of the two groups in the performance tests. This justified the assumptions made in the statistical analyses that the two groups were from the same population and therefore it was valid to compare their performances.

The factors or constructs on which the two treatment groups were compared were refined on the basis of a factor analysis, which is described in chapter 6. The factor analysis of the data from the MAQ guided the modification of the original constructs. As noted in chapter 6 the original constructs, which guided the design of the MAQ questionnaire, bore only a slight resemblance to the constructs derived from the factor analysis. However, the researcher notes that the factors pre factor analysis, and the factors post factor analysis were not mutually exclusive.

### 7.5.3 Attitudes to Computers and CAI

As noted earlier, unlike that for the MAQ, no hypotheses were generated for the computer attitude questionnaires. The reasons for not generating any hypotheses to test the data from the two computer attitude questionnaires, CSQ1 and CSQ2, are discussed in chapter 6. Very briefly this was due to questions on the validity of student responses given their general lack of exposure to computers. Therefore only general trends in the students' disposition to computers and the CAI software were noted from the CSQ1 and CSQ2 data. Questions posed and the subsequent hypotheses generated at the beginning of the study that the two questionnaires were to address were thus abandoned.

Nonetheless the following general questions underlie the analysis of the CSQ1 and CSQ2 data in noting general trends in students' dispositions to computers.

5. Do PNG distance education matriculation students have positive or negative attitudes towards the use of computers for learning?
6. Do PNG distance education matriculation students have positive or negative attitudes towards the introduction of CAI to the teaching of pre-university mathematics?
7. Do PNG distance education, matriculation students see CAI as an effective medium of mathematics instruction to distance students?
8. Does exposure to CAI improve the level of motivation and interest in mathematics in the students?
7. Do PNG matriculation students enrolled through the distance mode see the situation where the student is able to learn at his or her own pace as a desirable outcome?
8. Do PNG matriculation students enrolled through the distance mode see the situation of reduced dependence on a human tutor as a desirable outcome?

### 7.5.4 Discussion of the Noted Trends in the CSQ2 Data

The CSQ questionnaire design of pre and post attitude questionnaires was intended to investigate differences in attitudes to computers and the CAI software amongst the CAI students before and after the computer experience. This was abandoned in line with the decision not to hypothesise on the results of the questionnaires for reasons noted earlier. General trends in the CAI students' responses to both questionnaires can be noted from both the pilot study results in tables 4.7 and 4.8 in chapter 4 and the main study in tables 6.2 and 6.3 in chapter 6.

In summary, the CAI students' attitudes to computers and the CAI software was markedly positive and enthusiastic. Given that up to 55 percent of the students in the main study were using computers for the first time, particularly in this context, the positive attitudes and enthusiasm towards the computer-based system of instructions could very well be due to the novelty of the medium (Clark, 1983). Others have also noted positive attitudes towards computers by students involved in CAI (e.g. Fletcher-Flinn and Gravatt (1995)). Fletcher-Flinn and Gravatt also noted from the 120 studies they reviewed that computers did not change students' attitudes very much and proposed as a possible reason the fact that students were very highly motivated to start with.

The uncertainty regarding the reasons for the positive attitudes to computers unfortunately cannot be disregarded, as there are no mechanisms provided in the present study to discount them. That is left for future studies to determine.

In noting general trends in students' attitudes to computers and the CAI software particular attention was paid to those in CSQ2. This was because the responses at least reflect some familiarity with computers, however little that was. The following discussion of observations, therefore, stems from students' responses in CSQ2 on the following aspects of CAI: colour, graphics, animation, navigation, feedback capability, individualised learning and independence from human tutor.

*Table 7.3: Response Patterns to Specific Features of the CAI Software in CSQ2*

| Item No. | Questionnaire Item | SA/A % | NS % | SD/D % | Item + or - |
|---|---|---|---|---|---|
| | | | | | |
| | **Dependence on Human Presence/Own Pace** | | | | |
| 15 | Learning mathematics through CAI for me lacks the sense of presence that a human tutor provides. | 49 | 8 | 43 | - |
| 16 | I would rather attend face-to-face tutorials with a human tutor than go through CAI again. | 20 | 14 | 66 | - |
| 21 | I find CAI to be less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorial. | 14 | 20 | 66 | - |
| 24 | CAI is better in mediating mathematics learning for me than other more traditional mediums such as course booklets and face-to-face tutorials. | 63 | 11 | 26 | + |
| 45 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | 20 | 11 | 69 | - |
| 44 | Working at my own pace using CAI is not as effective in learning mathematics as attendance at face-to-face tutorials. | 11 | 20 | 69 | - |
| 35 | Being able to work at my own pace in covering the units in mathematics 2 is one aspect of CAI I find useful. | 91 | 6 | 3 | + |
| | | | | | |
| | **Colour, Graphics and Animation** | | | | |
| 30 | The colour, graphics and animation in CAI has made the learning of concepts in mathematics 2 interesting and easy for me. | 86 | 8 | 6 | + |
| 40 | The colour, graphics and animation in CAI is distracting for me making CAI less effective as a learning tool. | 3 | 3 | 94 | - |
| | **Navigation** | | | | |
| 36 | The navigation capabilities provided in the CAI software has made my mathematics learning enjoyable and effective. | 91 | 3 | 6 | + |
| 39 | The navigation capabilities provided in the CAI software is clear and logical so that I know exactly where I am in the CAI-mediated mathematics lessons. | 88 | 9 | 3 | + |
| 42 | The navigation capabilities provided in the CAI software makes no difference for me in learning mathematical ideas. | 54 | 11 | 35 | - |
| | **Feedback** | | | | |
| 41 | The capability of CAI to provide immediate feedback is no different to looking up the answers to exercises provided in the back of a unit booklet. | 63 | 8 | 29 | - |
| 43 | The ability of the CAI software to provide immediate feedback in the exercises provided in some topics has increased my interest and effectiveness in mathematics 2. | 91 | 3 | 6 | + |

Key: SA = Strongly Agree A = Agree NS = Not sure D = Disagree SD = Strongly Disagree

Only a few comments on the various aspects of CAI, as noted in table 7.3, are necessary. From table 7.3, it is clear that the students were not so certain about rating CAI against face-to-face tutorials. Although CAI was rated highly compared to face-to-face instruction or human presence, the level of uncertainty as well as a relatively high percentage of students choosing the opposite view to a positive CAI view shows that students were not very certain about this aspect of CAI. The researcher conjectures that more experience with computers and CAI course software would have resolved this uncertainty.

Working at one's own pace or the capacity of CAI to facilitate individualised learning was rated highly as a positive aspect of CAI, with 91 percent agreeing and 6 percent not sure and only 3 percent disagreeing. Unfortunately, only one item sought information exclusively on this aspect therefore one cannot read much into the response to this item. However literature does show that advantages of CAI include individualised instruction and self-pacing as very important aspects of CAI besides other advantages (Lauzon, 1989). Individualised learning is such a major defining characteristic of CAI that future research could specifically investigate more thoroughly the facilitation of this capability of CAI in the PNG distance education context.

The students' attitude to aspects of CAI such as colour, graphics and animation was very positive from the responses to the two items that dealt with these aspects of the CAI software. Enhancements such as colour and graphics are often associated with the facilitation of motivation in the students to engage with the learning task (Nicol and Anderson (2000); Farrow (1992)). Animation was not considered as a separate aspect of CAI that enhances its potential to mediate learning but as is evident from literature (chapter 3) is a crucial aspect of CAI especially in spatial visualisation among some students.

The Navigation aspect of the CAI software was also rated highly positive. However, the response to one of the three items that dealt with this aspect of CAI shows some inconsistency in the response pattern, hence casting doubt on the validity of the students' attitudes. Nonetheless literature shows that such hypermedia aspects as navigation are crucial enhancements of CAI. For example Perzylo (1993) notes that such multimedia resources as hypermedia create a web of relationships mirroring the structure of human thinking.

The CAI capability to provide feedback was also rated highly as a positive aspect of the CAI software, although item 41 shows a somewhat subdued response. This may have been due to a misunderstanding because of the way the item was worded. Unfortunately, the potential for misunderstanding this item was only recognised in hindsight.

Overall, therefore, the students' attitude to the use of computers and the implementation of a CAI-mediated mathematics tutorial system for IDCE was very positive. This is despite the doubts on the validity as well as consistency of student responses as noted in chapter 4 and 6.

## 7.6 Performance in the Mathematics Achievement tests: Pretest, Posttest and Final Examination

The comparative performances of CAI and TM students in mathematics was investigated through three achievement tests: pretest, posttest and final examination. As stated in section 6.3.1 the pretest and the posttest were the same except for a few cosmetic differences and the 7-week gap between their applications. Investigation questions were posed for each of the three tests which were then used to generate hypotheses that were tested comparing performances between the CAI group and the TM group in the tests using the Mann Whitney U test.

The following were the research questions investigated through the application of the three achievement tests.

### 7.6.1 Research Questions

#### 7.6.1.1 Performance Differences between Pretest and Posttest

2. Is there a significant difference in the students' level of competence in mathematics 2 concepts between the results in the pretest and the results in the posttest?

This question investigated whether any learning took place in the seven weeks of tutorials between the completion of the pretest and posttest. The hypothesis that the Wilcoxon Signed Ranks Test tested for the above question was that there was no significant difference in performance between the pretest and the posttest. A "not significant" result would imply that no learning took place by either method in the 7-weeks period of tutorial instructions between the sitting of the pretest and the sitting of the posttest. This would certainly point to design problems in the course mathematics 2.

The results of the Wilcoxon Signed Ranks Test are reported in tables 6.12a and 6.12b in chapter 6. Tables 6.12a and 6.12b indicate that the difference is significant, that is, rejecting the hypothesis, significant learning did take place in the 7-week period of instructions as a net effect of both modes of instructions. The fact that overall there was a significant difference in the performance of the study population in the two tests implies that any differences noted between the two groups in the posttest can be attributed to tutorial mode with some degree of confidence. Thus the result helps to clear the way to then test for the comparative differences in performance due to the two different modes of instructions.

#### 7.6.1.2 Performance Differences between CAI and TM Students in the Pretest

2. Is there a significant difference in performance between the CAI group and the TM group in the pretest?

For the pretest, there is only one investigation question and a hypothesis generated from that question. Attendance levels at CAI tutorials, by the CAI group, were not an important factor in the analysis of comparative performances in the pretest because the students completed this test prior to the commencement of tutorials. The assumption was that all mathematics students were at the same level of competence in mathematics concepts, at the commencement of the tutorials. Moreover, a significant difference in the pretest would have invalidated any comparison of the posttest results because the two groups would have started from different levels of mathematical competency.

The pretest was used mainly as a starting reference to quantify differences in achievement gains in the period of instruction by comparing the students' level of competence in mathematics 2 concepts at the beginning of the course and halfway through the course some 7 weeks later.

#### 7.6.1.3 Performance Differences between CAI and TM Students in the Posttest

3. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest, with attendance at CAI tutorials by the CAI group, of at least one session?
4. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest, with attendance at CAI tutorials by the CAI group, of at least two sessions?

5. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest, with attendance at CAI tutorials by the CAI group, of at least three sessions?
6. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest, with attendance at CAI tutorials by the CAI group, of at least four sessions?
7. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest, with attendance at CAI tutorials by the CAI group, of at least five sessions?
8. Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least 6 or 7 sessions?

In comparison to that for the pretest there were 6 investigation questions each in the posttest and the final examination, based on attendance levels by CAI students at CAI tutorial sessions. This decision resulted from the observed inconsistent attendance at CAI tutorials by the CAI group. The observed decrease in tutorial size of the CAI group, towards the end of the 7-week period of CAI tutorials, was discussed in an earlier section in this chapter. Each investigation question in the posttest and the final examination was associated with an appropriate hypothesis as noted in chapter 6.

#### 7.6.1.4 Performance Differences between CAI and TM Students in the Final Examination

7. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least one session?
8. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least two sessions?

9. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least three sessions?
10. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least four sessions?
11. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least five sessions?
12. Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least six or seven sessions?

The findings in each of the three tests in a summarised form appear below.

### 7.6.2 Findings

#### 7.6.2.1 Pretest

*Table 7.4 Differences in Performance in the Pretest*

| Pretest | |
|---|---|
| **Investigation Question** | **Finding** |
| Is there a significant difference in performance between the CAI group and the TM group in the pretest? | No |

This result confirmed expectations that all students were at the same level of understanding of mathematical concepts before the treatment period began. Thus no significant differences in performance were expected between students in the CAI group and the TM group. Significant differences in the pretest would have invalidated any comparison of the two groups on the grounds that the two groups were undergoing the treatment from different starting points.

#### 7.6.2.2 Posttest

**Investigation Question:** Is there a significant difference in performance between the CAI Group and the TM Group in the posttest with attendance at CAI tutorials by the CAI group of at least:

*Table 7.5 Differences in Performance in the Posttest*

| Posttest | |
|---|---|
| **Attendance Situation** | **Finding** |
| One session | No |
| Two sessions | No |
| Three sessions | No |
| Four sessions | No |
| Five sessions | No |
| Six sessions | No |

In all cases there were no significant differences in performances between the two groups, but as noted in chapter 6 table 6.3, there was a noticeable trend in the pattern of variance of the p-values generated in the test of hypotheses. From figure 6.2, which is reproduced on page 257 as figure 7.1, the pattern clearly showed that the P-values definitely approached significance as attendance at CAI tutorials by the CAI group increased. The researcher concludes from this pattern that two factors curtailed this improving pattern: duration of the tutorial sessions (only 7 weeks) and the rather small sample size due to decreasing attendance levels of the already fairly small sample to begin with.

The interesting question that this observation poses is, would the differences in performance between the CAI and the TM groups have been significant had the CAI tutorials continued beyond just seven weeks and attendance levels at the CAI tutorials had remained steadily high?

The trends derived from the data suggest that the answer to the question may be in the affirmative, that an increased duration for CAI tutorials and regular attendance at such tutorials may have made a difference in the comparative performances of the two groups of students with CAI taught students doing better. If it were the case it would be consistent with the literature, e.g. Khalili and Shashaani

(1994), as noted in chapter 3, that the longer the treatment the more significantly better the results.

Is CAI better than FTF tutorials? The researcher does not think that the data from the present study is sufficient on its own to answer that question either in the affirmative or otherwise with complete confidence in this case. But the essential point of the present study was to determine if CAI is as effective as current practices in IDCE, including face-to-face instruction.

In noting the trend in the p-values the researcher was aware of the possibility that the results were quite accidental and were therefore not valuable observations. But the results obtained in the analysis of the comparative performances of the two groups in the final examination somewhat supported the view that the noted trend in the variance of p-values in the analysis of the posttest was important.

#### 7.6.2.3 Final Examination

The parallel analysis to the posttest, regarding the performances of the two groups in the final examination, was presented in section 6.8.4 in chapter 6. A summary is presented here in table 7.7.

**Investigation Question:** Is there a significant difference in performance between the CAI Group and the TM Group in the final examination with attendance at CAI tutorials by the CAI group of at least:

*Table 7.6 Differences in Performance in the Final examination*

| Final Examination | |
|---|---|
| **Attendance Situation** | **Finding** |
| One session | No |
| Two sessions | No |
| Three sessions | No |
| Four sessions | No |
| Five sessions | Yes |
| Six or Seven sessions | Yes |

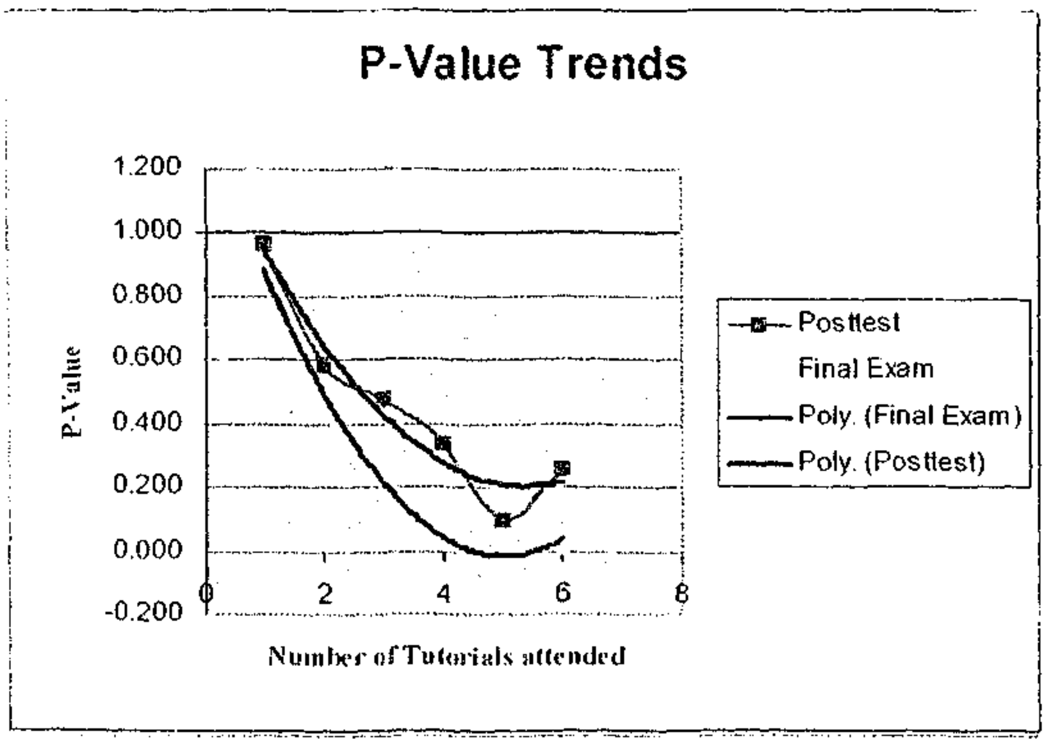
The summary of the 6 situations in table 7.6 shows that the p-values obtained in the analysis of the data from the final examination reached significance as the number of tutorials increased. This is the same pattern noted in the results for the posttest except that in the posttest none of the p-values reached significance. In the final examination significance was reached when attendance at CAI tutorial sessions by the CAI group was at least 5, somewhat confirming the view prevalent in literature that the longer the treatment the better the results (e.g. Khalili and Shashaani (1994)).

Table 6.27 and figure 6.2 from chapter 6 are re-presented below as table 7.7 and figure 7.1 to show the patterns of variance of p-values with increasing attendance at CAI tutorials by members of the CAI group. The trends shown in figure 7.1 provide the background to the following conclusions.

*Table 7.7: Table of P-Values*

| | Posttest | Final Ex |
|---|---|---|
| Attendance | P-Value | P-Value |
| At least 1 | 0.967 | 0.928 |
| At least 2 | 0.590 | 0.449 |
| At least 3 | 0.476 | 0.148 |
| At least 4 | 0.342 | 0.133 |
| At least 5 | 0.102 | 0.003 |
| At least 6 | 0.260 | 0.008 |

*Figure 7.1: Graphical Demonstration of the Trend in P-Values in the Comparative performances of the CAI and TM Tutorial Groups in the final examination by Tutorial Attendance of the CAI Group*



As noted in chapter 6 the posttest was applied almost immediately at the end of the seven weeks of tutorials, whereas the final examination was applied after another seven weeks had elapsed from the end of the period of research-related observations. This strongly suggests that longer-term retention of mathematical concepts learned using the computer-based tutorials is significantly better.

The results also further suggest that in the longer-term, computer-based tutorials in mathematics 2 are more beneficial than TM and at the very least as effective as the current practices in mathematics tutoring in IDCE.

#### 7.6.3 Literature Support for the findings of the Present Study

The findings in the present study are generally supported by many studies as noted for instance in the many meta-analyses on studies comparing CAI to TM, as well as by the results of the numerous reports of individual studies noted in chapter 3. For instance a specific study for instance that had results similar to the present study and conducted in a setting that is somewhat reminiscent of the present study is that by Robert and Phalavonk (1992). In their study of first year University students in Thailand Robert and Phalavonk found that CAI-taught students not only did better than their TM counterparts but also did better on long-term retention. An unexpected finding in their study was that students taught a topic through CAI also exhibited superior performances on topics not taught through CAI over those who had no experience of CAI at all.

A similar finding could not be confirmed for the present study because the focus of the present study is different, hence this particular phenomenon could not be observed specifically. However, the observation in the present study of better performances by CAI students who had attended more CAI tutorials to TM students in the final examination could well be a demonstration of a similar phenomenon. The better performance by CAI students in the final examination could well include better performances in the other 4 topics in the Mathematics 2 course not taught through CAI. Further research could investigate this link specifically.

The four topics not covered in the present study were taught to students from both groups via the TM method after the end of the seven weeks of research-related teaching. As noted in chapter 5, the seven weeks of research-related teaching in the main study were the first 7 weeks of the 14-week first semester of 2000 at UPNG.

## 7.7 Discussion

The basic aim of the present study was to investigate the efficacy of a computer-based system of instruction. In working towards that aim the essential issue that the researcher was looking at was whether a computer-based system of instruction is as good as the traditional method of teaching and learning mathematics in IDCE. The researcher contends that this "baseline" aim was achieved, as the results show.

The traditional method (TM), as defined in chapter 4-methodology, in the context of the present study, included text-based tuition, self-study and face-to-face tutorials, whereas CAI as a method of teaching and learning included text, self-study and computer-assisted instruction. That CAI was at least as effective as the traditional method was clearly demonstrated in the study. It could well be better than current practices in teaching and learning mathematics in IDCE but this can only be established through further research.

Moreover, it was not the researcher's aim nor interest to consider whether CAI is necessarily better than other modes of teaching and learning necessarily, because the broad picture that is being promoted in the design of the present study is computer-based learning systems as tools. Like all tools CAI can also be used effectively as well as ineffectively in teaching and learning. Regardless of whether instructions are mediated through CAI or some other way, ultimately, there will always be human intervention somewhere. Computer-based learning tools such as CAI are only as good as the thinking and planning that preceded their implementation by those involved in their application. As a learning tool though, CAI is as effective and in certain situations could even be more effective than other modes of teaching and learning. Fletcher-Flinn and Gravatt (1995: p. 232 ) supported this view in noting that "CAI is on a par with any other medium of instruction and when other criteria are considered may far surpass them".

This is clearly a significant conclusion in that the usual practice (TM), as noted before, also included face-to-face instruction. This is often equated with the ideal instructional situation, as noted in foregoing discussions. In fact the main difference in the instruction of the two groups was that one group also had face-to-face instructions in addition to text and self-study while the other had CAI without direct teaching from the human tutor, in addition to text and self-study.

The findings of the present study show that CAI can at least produce the same effects in the teaching and learning of mathematics that existing practices in IDCE in PNG produce.

Particularly in the field of mathematics where, even in face-to-face classroom-based teaching, most of the work is algorithmic in nature, a CAI method should be expected to do just as well if not better. Computer programs such as CAI often operate at an algorithmic level and mathematics as a subject that is basically algorithmic finds a ready tool in CAI.

There is much discussion in the literature that CAI is not very good at teaching higher order concepts. In this regard and in the context of the present study the researcher contends the following.

1. For current mathematics courses in IDCE, this is not a problem given that the level of thinking required is not of such high order. For instance in attempting to classify the course objectives of mathematics 2 into the 6 categories of Bloom's Taxonomy in writing the pretest/posttest, it was found that almost all objectives fitted into just two categories: knowledge and application. Thus even if it is true that CAI is only good for teaching simpler concepts, for the IDCE mathematics courses including mathematics 2, CAI is adequate and effective. Even allowing for the level of sophistication of CAI from the seventies and eighties referred to in most of the literature reviewed, CAI supplemented with written materials can adequately mediate learning in courses such as mathematics 2. More recently computer-based applications with which CAI software are developed have undergone major improvements allowing for more sophistication in type and level of CAI possible. As noted by Fletcher-Flinn and Gravatt for instance (1995) research data on CAI applications since the introduction of more recent computer tools such as hypertext,

hypermedia and other recently introduced multimedia combinations have yet to be assessed. It is not yet well known what the CAI programs incorporating the newer multimedia tools are capable of.

2. The contention that CAI does not facilitate higher order thinking assumes that CAI would not be used with other modes of teaching. There is no reason why face-to-face teaching could not be incorporated also into the optimum mode of teaching and learning possible. There are also other computer-based tools for learning mathematics already noted in foregoing discussions such as computer-based mathematics learning environments, which provide for learning at the epistemological level (Balacheff and Kaput (1996)). These mathematics learning environments can be incorporated with CAI applications to cater for a more comprehensive level of mathematics teaching and learning. Moreover computers are becoming more and more versatile and CAI programs are becoming more sophisticated.

Thus the argument that because CAI does not provide for higher order learning then it is not an effective mode of learning is rendered groundless, especially in the context in which the present study is situated.

CAI is just one of the many computer-based systems of learning that could be employed in teaching mathematics. Amongst computer-based programs which involves changing the mathematical experience of learners at the epistemological level are microworlds such as Logo Turtle Geometry. The traditional formalisms and graphics of algebra, linear algebra and calculus are also catered for through the use of interactive computer-based systems such as MatLab, mathematica and other like software (Balacheff and Kaput (1996)).

It should now be abundantly clear that the researcher is not an advocate of any particular mode of mathematical instruction per se but rather advocates the best use of all resources available including computer-based methods to optimise mathematics learning. Through the increasing availability of computer technologies computer-based methods of teaching and learning are now becoming more feasible as an educational tool in the PNG context. The present study is a pioneering effort, which looks at just one aspect of this direction of teaching and learning methods.

## 7.8 Limitations of the Study

There are a number of limitations to the present study. In hindsight the variables in the investigation could have been better controlled, although the direction the study took was dictated to a large extent by the prevailing circumstances. The prevailing circumstances also determined the sample sizes in the study, which admittedly were comparatively small.

While the study presents some evidence of significant differences in performances due to TM and CAI methods, with the results favouring CAI-taught students, the researcher urges caution in how the findings of the present study are interpreted. The present study should be seen for what it is, a pioneering effort in the mould of a super pilot study that provides a base to build on in the researched application of computer-based teaching and learning modes such as CAI in distance education in PNG. As stated before the researcher basically hoped to establish that CAI as a mode of teaching and learning is as effective as more traditional modes. The researcher believes that this aim has largely been fulfilled.

## 7.9 Implications of the Results for Distance Education in PNG

Distance education in PNG, as noted in preceding chapters, has been practiced more as an adjunct to the traditional classroom-based FTF mode rather than as a mode of learning that is relevant and significant on its own right. For instance in the model of distance education followed at UPNG the distance or external program basically emulates the internal university program which experience shows has been problematic. It has also been largely text-based with limited face-to-face teaching.

Distance education has also suffered from an image problem that it is not equal to traditional education. Distance education in other countries is now increasingly being mediated through technology to improve this image problem. Many distance programs are providing technology means to expose distance students to a more varied experience of learning aside from written instructional materials without losing the advantages of distance. These conclusions from the literature provided the impetus to adopt a computer-based mode to teach mathematics to distance students at UPNG.

From first-hand observation the researcher noted that existing practices were not working very well, especially in the area of mathematics as a compulsory subject. While a few students were succeeding the vast majority of students were not doing as well. In an effort to improve on the existing practices, which were seen to be failing, the present study was proposed to investigate a CAI approach to teaching mathematics. The CAI mode was largely modelled on the existing limited face-to-face supplementary tutorials and were conducted parallel to them.

The largely positive results from the present study suggest that CAI should be incorporated into at least the teaching of mathematics in IDCE. This is not such a difficult mode of teaching and learning to implement, even in the PNG context. Small computer-laboratories in every University Centre can be established to facilitate a CAI tutorial program. A small computer laboratory would consist of 5 to 10 computers at most. A small computer laboratory also ensures a small class situation taking care of the problem of large classes in mathematics tutorials, which result in a lack of individual attention to each member of the tutorial class. Moreover aid foundations and organisations as well as companies in the private sector are more willing to sponsor tangible improvements such as a computer laboratory than other innovations for which they are solicited for assistance.

Moreover it is imperative now that serious thought is given to the development and implementation of computer-based teaching and learning systems such as CAI in PNG. The situation in PNG in the tertiary sector is such that distance education, with its attendant problems, is the only viable option left for the expansion of tertiary level education. Access to tertiary places is becoming more and more scarce as the nation's population booms without an equivalent expansion in the educational facilities. Since it is quite unlikely that there will be a boom in educational facilities in the immediate future other means of expansion of opportunity are being looked at. Distance education combined with computer-based technology is the current zeitgeist in the expansion of educational services in many places in the world.

In fact UPNG has just pre-empted the recommendations of the present study in announcing the establishment of four "Open Campuses" which will be substantial operations to focus on the delivery of tertiary education through the distance mode at the regional level. These "Open Campuses will begin operating in 2002. It is envisaged that the four "Open Campuses" will have the capacity to offer web-based or CD-ROM-based courses with various facilities including computer laboratories (Tobia, 2001).

As noted in the present study very little research has gone into the use of computer-based learning in PNG but the pressure to expand tertiary education places is such that the computer-based systems will be implemented with little or no research. In a situation like this the students who enrol first up end up as the guinea pigs on which the systems are tested. Unfortunately, as noted for instance by Bates (1991), the potential for expensive mistakes is very high when major innovations like computer-based learning systems are implemented with little informed research.

The present study has gone some way into looking at the theoretical basis for the adoption of computer-based systems in a distance education environment. In the end, given the current environment of acute shortages of tertiary places, the systems will be introduced and only experience will determine whether the venture has been worthwhile or not.

## 7.10 Recommendations

In making the following recommendations the researcher draws particular attention to the fact that in both the CAI and TM situations there was a human tutor present in the tutorial situation. While it is possible that a completely developed CAI program can be used by students on their own without the presence or assistance of a tutor, that is not the situation the present study promotes.

Numerous studies have shown the importance of group-based collaborative learning. For a traditional society like PNG this could well be the ideal learning situation. To that end therefore a computer laboratory based learning situation is recommended for CAI in PNG such that the student is within a peer group while taking advantage of the self-pacing abilities of CAI as well as the presence of a tutor. Moreover the number of students studying through IDCE with individual access to a computer is expected to be very low, therefore laboratory-based CAI is also the most viable option in this sense. Nonetheless the CAI program should also be developed to such an extent that individuals with computer resources could use it on their own without the presence of a tutor and without too much difficulty.

A few studies have looked at students working in pairs in a CAI environment and it is possible that such a cooperative, group-based environment would be better still in mediating learning among PNG distance students. It is therefore recommended that all university centres in PNG establish a computer laboratory as part of their centre facilities. The computer laboratory does not have to be big as long as it can facilitate small group tutorials. As shown in the present study, just one tutor can handle a large group of students in small laboratory sized groups over a week, going by the current practice of 2 hours per week of face-to-face tutorials per student per subject.

Together with the establishment of small computer laboratories of course, a concerted effort should be made at UPNG to develop CAI programs or purchase and adapt an existing one in the various courses available through distance. A good start would be with the few mathematics courses available through IDCE. A CAI tutoring system in mathematics would facilitate an independent, self-paced approach to teaching and learning which would seem to be the ideal compromise between the two extremes of insufficient tutorial assistance as mediated by text only, and spoon-feeding as currently happens in face-to-face tutorials.

## 7.11 Conclusion

CAI as mode of teaching and learning in the PNG education context, particularly in distance education, is viable. The present study set out to compare results in achievement tests between two groups of students, one group taught via CAI and the other through the traditional methods. The results suggest that CAI is at the very least as good as the TM method. The results in fact show that CAI students performed better consistently even though the results in most cases were not significant. There is a suggestion from the results of the study that the longer the length of exposure to the CAI teaching method the significantly better the results of

CAI-taught students compared to traditionally taught students other factors being equal.

The results of the present study also largely corroborated many earlier findings by others in the literature. Amongst the findings that were supported by the present study were that long-term retention is better with CAI, student engagement on task and focus is better with CAI, CAI improves motivation levels and CAI facilitates rapid learning. Moreover computer-based teaching and learning programs are being improved all the time with the incorporation of various types and levels of multimedia, enabling the emulation of more natural ways of learning. However the adoption of all computer-based teaching and learning systems should not be effected in a research vacuum.

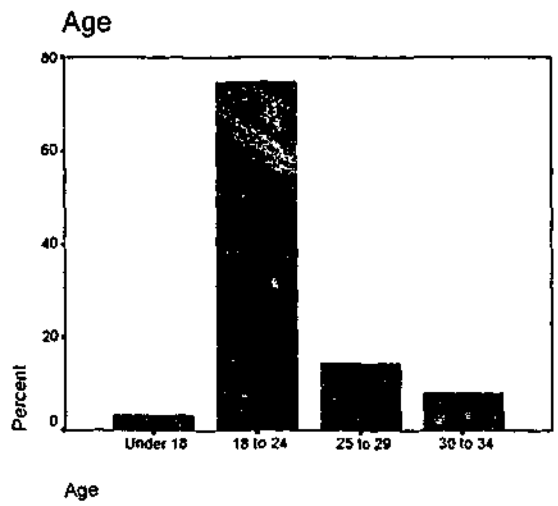
Further research is therefore urged, building on the results in the present study, to investigate the adoption of computer-based teaching and learning systems such as CAI as well as the world wide web in mediating instruction and learning, especially in distance education in PNG. The present study as a pioneering research effort in the area of computer based teaching and learning in distance education in PNG has identified, in a general way, some of the areas and directions in which research in this field in PNG can proceed. The study has also identified some pitfalls in methodology and procedures that can be avoided in similar studies in the field in the future.

## Pilot Study Appendices

## Appendix P1: Demographics of Combined Samples - Pilot Study

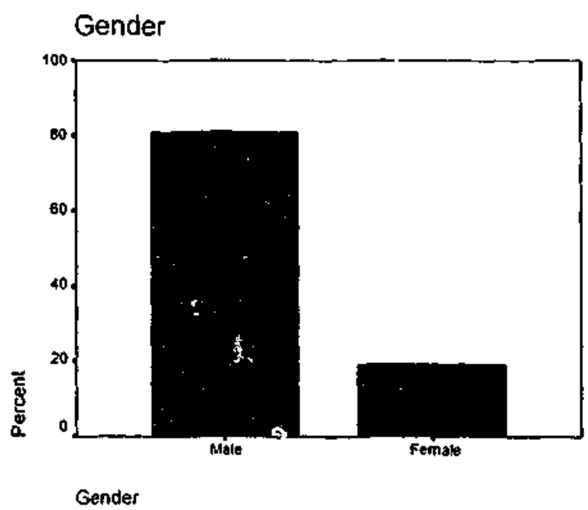
**Age**

| | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Under 18 | 2 | 3.2 | 3.2 |
| 18 to 24 | 47 | 74.6 | 77.8 |
| 25 to 29 | 9 | 14.3 | 92.1 |
| 30 to 34 | 5 | 7.9 | 100.0 |
| Total | 63 | 100.0 | |



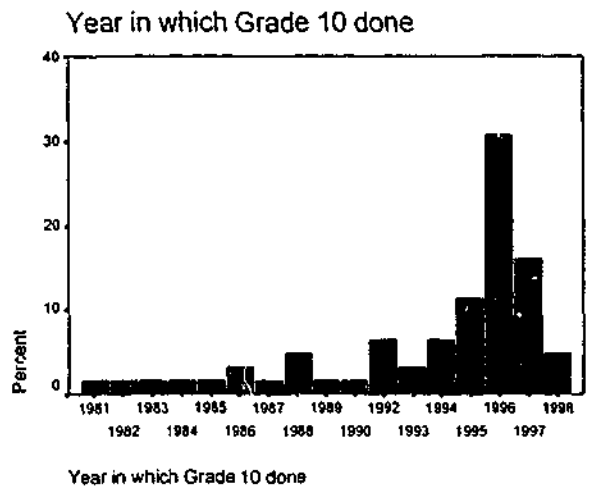

**Gender**

| | Frequency | Percent |
|---|---|---|
| Male | 51 | 81.0 |
| Female | 12 | 19.0 |
| Total | 63 | 100.0 |



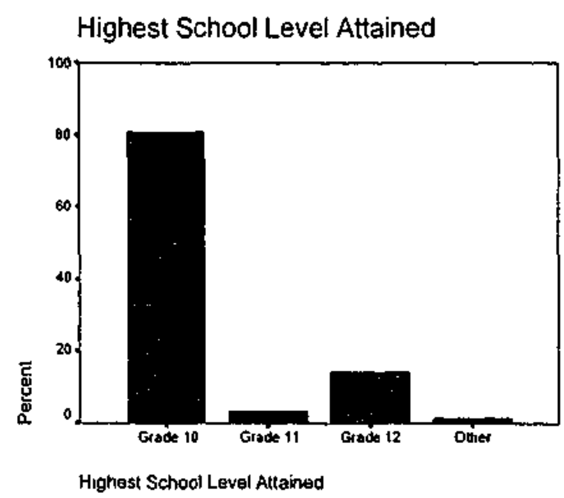
**Year in which Grade 10 done**

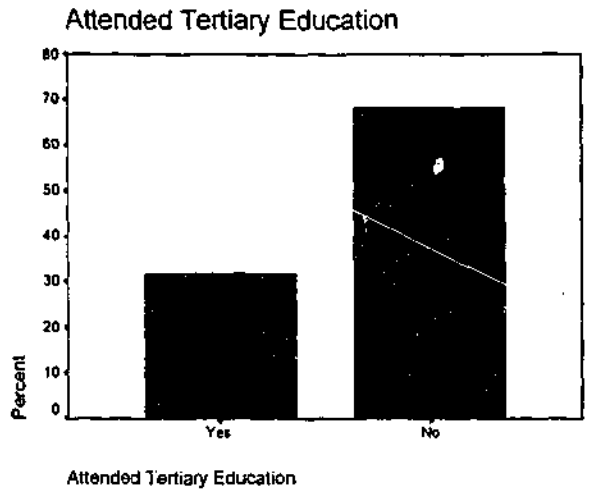
| | Frequency | Percent |
|---|---|---|
| 1981 | 1 | 1.6 |
| 1982 | 1 | 1.6 |
| 1983 | 1 | 1.6 |
| 1984 | 1 | 1.6 |
| 1985 | 1 | 1.6 |
| 1986 | 2 | 3.2 |
| 1987 | 1 | 1.6 |
| 1988 | 3 | 4.8 |
| 1989 | 1 | 1.6 |
| 1990 | 1 | 1.6 |
| 1992 | 4 | 6.3 |
| 1993 | 2 | 3.2 |
| 1994 | 4 | 6.3 |
| 1995 | 7 | 11.1 |
| 1996 | 19 | 30.2 |
| 1997 | 10 | 15.9 |
| 1998 | 3 | 4.8 |
| Total | 62 | 98.4 |
| Missing | 1 | 1.6 |
| Total | 63 | 100.0 |




**Highest School Level Attained**

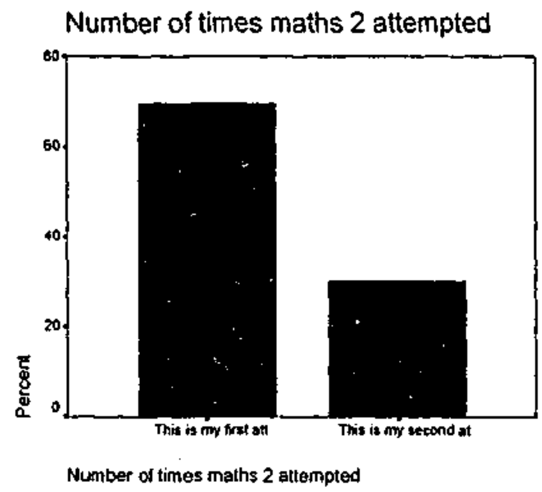
| | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Grade 10 | 51 | 81.0 | 81.0 |
| Grade 11 | 2 | 3.2 | 84.1 |
| Grade 12 | 9 | 14.3 | 98.4 |
| Other | 1 | 1.6 | 100.0 |
| Total | 63 | 100.0 | |





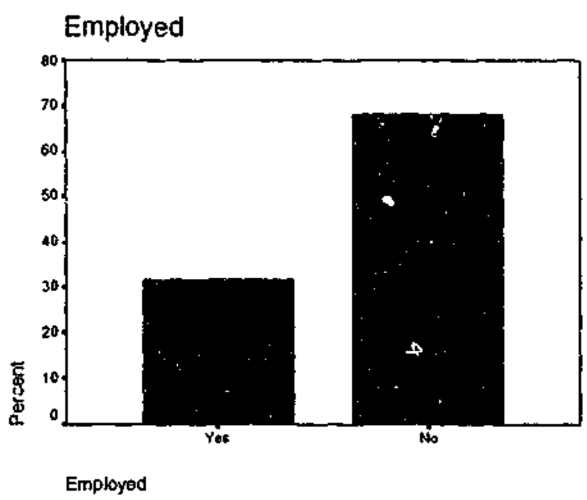

**Attended Tertiary Education**

| | Frequency | Percent |
|---|---|---|
| Yes | 20 | 31.7 |
| No | 43 | 68.3 |
| Total | 63 | 100.0 |




**Number of times maths 2 attempted**

| | Frequency | Percent |
|---|---|---|
| This is my first attempt | 44 | 69.8 |
| This is my second attempt | 19 | 30.2 |
| Total | 63 | 100.0 |




**Employed**

| | Frequency | Percent |
|---|---|---|
| Yes | 20 | 31.7 |
| No | 43 | 68.3 |
| Total | 63 | 100.0 |

**Occupation**

| | Frequency | Percent |
|---|---|---|
| Admin Officer | 1 | 1.6 |
| Bank Officer | 1 | 1.6 |
| Carpenter | 1 | 1.6 |
| Electrician | 1 | 1.6 |
| Nurse | 1 | 1.6 |
| Panel Beater | 1 | 1.6 |
| Policeman | 1 | 1.6 |
| Refrg&AC Technician | 1 | 1.6 |
| Research Officer | 1 | 1.6 |
| Sales Rep | 1 | 1.6 |
| Security Guard | 1 | 1.6 |
| Soldier | 3 | 4.8 |
| Student | 43 | 68.3 |
| Teacher | 4 | 6.3 |
| Technical Officer | 1 | 1.6 |
| Warder | 1 | 1.6 |
| Total | 63 | 100.0 |

# Mathematics Attitudes Survey

## Pilot Study

| | | | | | | |
|---|---|---|---|---|---|---|
| Q1 | Doing mathematics is a challenge that I enjoy. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q2 | Mathematics is so useful that it should be a required part of my professional skills. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q3 | I don't like mathematics because it is not relevant to my traditional culture. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q4 | Pre-University mathematics as it is taught at present is too foreign and not applicable to PNG students. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q5 | Pre-University mathematics is too divorced from PNG traditions and culture. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q6 | I get a great deal of satisfaction out of solving a mathematics problem. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q7 | There is no use for mathematics in PNG traditional culture. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q8 | It takes me a long time to understand a mathematical concept. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q9 | Mathematics is important for me to learn whether it is relevant to PNG traditional culture or not. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q10 | Mathematics will be useful to me in my profession. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q11 | I would like to study advanced mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Mathematics Attitudes Survey

| | | | | | | |
|---|---|---|---|---|---|---|
| Q12 | The thought of taking another mathematics course makes me sick | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q13 | I find mathematics to be very logical and clear. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q14 | I have always enjoyed studying mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q15 | Mathematics is necessary to keep the world running. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q16 | Mathematics in not important in everyday life. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q17 | Mathematics has contributed greatly to science and other fields of knowledge. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q18 | I am interested and willing to acquire further knowledge of mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q19 | Mathematics identified in traditional cultural activities should also be taught in pre-university mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q20 | Mathematics helps to develop a person's mind and teaches him or her to think. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q21 | I am able to figure out most of the equations I need to solve a mathematics problem. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Mathematics Attitudes Survey

| | | | | | | |
|---|---|---|---|---|---|---|
| Q22 | The pace of a mathematics course is so fast that it is impossible for the average student to learn the subject matter thoroughly. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q23 | Mathematics ideas exist in my home culture. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q24 | Methods of solving mathematics problems are useful in my home culture. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q25 | Mathematics is about useful and practical ideas. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q26 | I should be allowed to choose whether to study mathematics or not. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q27 | Mathematics is very interesting and I have usually enjoyed courses in this subject. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q28 | There are no useful mathematical ideas in traditional cultural activities. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q29 | I enjoy going beyond the stated course and trying to solve new problems in mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q30 | I would like to develop my mathematics skills and study this subject more. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q31 | An understanding of mathematics is needed by artists and writers as well as scientists. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Mathematics Attitudes Survey

| | | | | | | |
|---|---|---|---|---|---|---|
| Q32 | Mathematics is less important to people than art or literature. | O SA | O A | O NS | O D | O SD |
| Q33 | There is nothing creative about mathematics; its just memorizing formulae and things. | O SA | O A | O NS | O D | O SD |
| Q34 | Mathematics is needed in designing practically everything. | O SA | O A | O NS | O D | O SD |
| Q35 | Mathematics is dull and boring because it leaves no room for personal opinion. | O SA | O A | O NS | O D | O SD |
| Q36 | I have never liked mathematics and it is my most dreaded subject. | O SA | O A | O NS | O D | O SD |
| Q37 | Mathematics makes me feel uneasy and confused. | O SA | O A | O NS | O D | O SD |
| Q38 | Mathematics is a worthwhile and necessary subject. | O SA | O A | O NS | O D | O SD |
| Q39 | Mathematics makes me feel uncomfortable and nervous. | O SA | O A | O NS | O D | O SD |
| Q40 | I do not need mathematics to survive in the village. | O SA | O A | O NS | O D | O SD |
| Q41 | Mathematics is useful in traditional societies. | O SA | O A | O NS | O D | O SD |
| Q42 | I would avoid mathematics completely if that was possible and I could still continue my studies. | O SA | O A | O NS | O D | O SD |

# Appendix P3: Item Reliability Analyses for Overall (45 Items) MAQ Scale – Pilot Study

## CRONBACH'S A L P H A

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Alpha if Item Deleted |
|---|---|---|---|---|
| Q1 | 176.9821 | 216.1633 | .4179 | .8555 |
| Q2 | 176.6964 | 221.1607 | .4042 | .8570 |
| Q3 | 176.8571 | 213.4338 | .5697 | .8529 |
| Q4 | 177.3214 | 216.4039 | .3728 | .8563 |
| Q5 | 177.5000 | 212.8364 | .4862 | .8538 |
| Q6 | 177.0179 | 221.5815 | .1989 | .8599 |
| Q7 | 176.8214 | 220.0766 | .3319 | .8574 |
| Q8 | 178.3214 | 204.4766 | .5992 | .8501 |
| Q9 | 176.7500 | 228.0455 | -.0281 | .8619 |
| Q10 | 176.6607 | 217.0646 | .6338 | .8540 |
| Q11 | 176.8750 | 219.9659 | .3542 | .8571 |
| Q12 | 177.0536 | 213.9789 | .5643 | .8531 |
| Q13 | 177.5179 | 208.3269 | .6592 | .8500 |
| Q14 | 177.0536 | 215.1789 | .4964 | .8542 |
| Q15 | 176.9286 | 222.9039 | .1597 | .8605 |
| Q16 | 176.7679 | 214.3269 | .5282 | .8536 |
| Q17 | 176.5179 | 223.8906 | .1867 | .8596 |
| Q18 | 176.7321 | 219.4724 | .4277 | .8562 |
| Q19 | 177.4286 | 228.3948 | -.0483 | .8640 |
| Q20 | 176.6071 | 223.4065 | .2378 | .8589 |
| Q21 | 177.5893 | 218.9737 | .2970 | .8579 |
| Q22 | 178.7500 | 213.4636 | .3919 | .8559 |
| Q23 | 177.6607 | 221.6464 | .1839 | .8603 |
| Q24 | 177.7679 | 217.4906 | .3539 | .8568 |
| Q25 | 176.8393 | 223.7373 | .2109 | .8592 |
| Q26 | 177.7143 | 229.2987 | -.0789 | .8679 |
| Q27 | 176.8929 | 216.8974 | .5802 | .8542 |
| Q28 | 177.6250 | 219.7295 | .2664 | .8585 |
| Q29 | 177.2321 | 217.9633 | .4147 | .8559 |
| Q30 | 176.7857 | 221.1896 | .3525 | .8574 |
| Q31 | 176.8571 | 220.4519 | .3292 | .8574 |
| Q32 | 177.2857 | 220.3169 | .2109 | .8600 |
| Q33 | 177.8393 | 221.3373 | .1118 | .8647 |
| Q34 | 176.9286 | 225.0494 | .1014 | .8611 |
| Q35 | 177.1250 | 223.4568 | .1425 | .8608 |
| Q36 | 176.8929 | 214.8974 | .5265 | .8538 |
| Q37 | 177.6607 | 208.4828 | .4958 | .8531 |
| Q38 | 176.8929 | 221.2610 | .3209 | .8577 |
| Q39 | 177.5893 | 207.8101 | .5422 | .8519 |
| Q40 | 177.3036 | 219.8880 | .2277 | .8596 |
| Q41 | 177.7321 | 221.5088 | .2032 | .8598 |
| Q42 | 177.2857 | 215.4805 | .3650 | .8565 |
| Q43 | 176.9643 | 220.7623 | .2314 | .8592 |
| Q44 | 178.7857 | 214.7532 | .3713 | .8564 |
| Q45 | 177.3750 | 217.8023 | .2760 | .8587 |

Reliability Coefficients

N of Cases = 56.0 N of Items = 45

Alpha = .8601

# Appendix P4: Summary Statistics for the MAQ Data – Pilot Study

| | N | Mean | Median | Std. Dev. | Skewness | Std. Err. of Skewness | Kurtosis | Std. Err. of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Question 1 | 63 | 4.32 | 4.00 | .86 | -2.096 | .302 | 6.049 | .595 |
| Question 2 | 63 | 4.56 | 5.00 | .59 | -.953 | .302 | -.043 | .595 |
| Question 3 | 63 | 4.37 | 5.00 | .87 | -1.255 | .302 | .759 | .595 |
| Question 4 | 63 | 3.94 | 4.00 | .97 | -.760 | .302 | .253 | .595 |
| Question 5 | 63 | 3.78 | 4.00 | .97 | -.613 | .302 | .436 | .595 |
| Question 6 | 63 | 4.27 | 4.00 | .88 | -2.014 | .302 | 5.288 | .595 |
| Question 7 | 62 | 4.35 | 5.00 | .79 | -1.143 | .304 | .889 | .599 |
| Question 8 | 62 | 2.87 | 3.00 | 1.26 | .048 | .304 | -1.298 | .599 |
| Question 9 | 63 | 4.52 | 5.00 | .53 | -.424 | .302 | -1.138 | .595 |
| Question 10 | 63 | 4.60 | 5.00 | .55 | -1.010 | .302 | .036 | .595 |
| Question 11 | 63 | 4.40 | 5.00 | .68 | -.703 | .302 | -.608 | .595 |
| Question 12 | 63 | 4.19 | 4.00 | .78 | -.561 | .302 | -.467 | .595 |
| Question 13 | 63 | 3.68 | 4.00 | .98 | -.691 | .302 | -.088 | .595 |
| Question 14 | 63 | 4.17 | 4.00 | .83 | -1.205 | .302 | 1.498 | .595 |
| Question 15 | 63 | 4.33 | 5.00 | .88 | -1.451 | .302 | 2.343 | .595 |
| Question 16 | 63 | 4.52 | 5.00 | .80 | -2.225 | .302 | 6.130 | .595 |
| Question 17 | 63 | 4.76 | 5.00 | .61 | -4.117 | .302 | 22.252 | .595 |
| Question 18 | 63 | 4.56 | 5.00 | .62 | -1.071 | .302 | .154 | .595 |
| Question 19 | 63 | 3.76 | 4.00 | .84 | -.544 | .302 | .826 | .595 |
| Question 20 | 63 | 4.60 | 5.00 | .61 | -1.290 | .302 | .659 | .595 |
| Question 21 | 63 | 3.71 | 4.00 | .87 | -.770 | .302 | .020 | .595 |
| Question 22 | 62 | 2.53 | 2.00 | 1.11 | .803 | .304 | -.019 | .599 |
| Question 23 | 63 | 3.56 | 4.00 | .96 | -.665 | .302 | .227 | .595 |
| Question 24 | 62 | 3.45 | 4.00 | .94 | -.787 | .304 | .695 | .599 |
| Question 25 | 62 | 4.45 | 4.50 | .59 | -.543 | .304 | -.602 | .599 |
| Question 26 | 63 | 3.51 | 4.00 | 1.20 | -.737 | .302 | -.307 | .595 |
| Question 27 | 63 | 4.35 | 4.00 | .60 | -.776 | .302 | 2.169 | .595 |
| Question 28 | 63 | 3.63 | 4.00 | .90 | .124 | .302 | -.872 | .595 |
| Question 29 | 63 | 3.98 | 4.00 | .79 | -.573 | .302 | .168 | .595 |
| Question 30 | 63 | 4.48 | 5.00 | .59 | -.629 | .302 | -.526 | .595 |
| Question 31 | 63 | 4.43 | 5.00 | .69 | -1.110 | .302 | 1.251 | .595 |
| Question 32 | 63 | 3.95 | 4.00 | 1.07 | -.966 | .302 | .393 | .595 |
| Question 33 | 63 | 3.52 | 4.00 | 1.35 | -.555 | .302 | -1.036 | .595 |
| Question 34 | 63 | 4.30 | 4.00 | .75 | -1.034 | .302 | 1.097 | .595 |
| Question 35 | 63 | 4.16 | 4.00 | .85 | -1.138 | .302 | 2.027 | .595 |
| Question 36 | 63 | 4.35 | 5.00 | .83 | -1.448 | .302 | 1.982 | .595 |
| Question 37 | 63 | 3.59 | 4.00 | 1.21 | -.714 | .302 | -.392 | .595 |
| Question 38 | 63 | 4.35 | 4.00 | .63 | -.825 | .302 | 1.730 | .595 |
| Question 39 | 63 | 3.67 | 4.00 | 1.18 | -.721 | .302 | -.485 | .595 |
| Question 40 | 63 | 3.90 | 4.00 | 1.01 | -.866 | .302 | .177 | .595 |
| Question 41 | 62 | 3.53 | 4.00 | .90 | -.448 | .304 | .015 | .599 |
| Question 42 | 63 | 3.97 | 4.00 | 1.03 | -1.120 | .302 | 1.315 | .595 |
| Question 43 | 62 | 4.32 | 4.50 | .88 | -1.873 | .304 | 4.761 | .599 |
| Question 44 | 62 | 2.48 | 2.00 | 1.07 | .587 | .304 | -.846 | .599 |
| Question 45 | 61 | 3.85 | 4.00 | 1.06 | -.990 | .306 | .775 | .604 |

# Computer Attitudes Survey Questionnaire 1

## Pilot Study

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## SECTION A General Information

| | | |
|---|---|---|
| Q2 | State very briefly in a sentence why you decided to join the CAI class instead of TM. | ____________________ ____________________ |
| Q3 | I have used a computer before. | ○ Yes ○ No |
| Q4 | I have used computers before in connection with; | ○ Computer Applications (e.g. word processing, spreadsheets etc.)<br>○ Computer Games<br>○ Computer Course<br>○ Other (specify):________<br>○ This is my first experience with computers |
| Q5 | I find handling or operating a mouse; | ○ V Difficult ○ Difficult ○ Easy ○ Very Easy |
| Q6 | I find handling or operating a computer keyboard; | ○ V Difficult ○ Difficult ○ Easy ○ Very Easy |
| Q7 | I find reading a line of text on the computer screen; | ○ V Difficult ○ Difficult ○ Easy ○ Very Easy |

# Computer Attitudes Survey Questionnaire 1

## SECTION B Attitude to Computers

| | | | | | | |
|---|---|---|---|---|---|---|
| Q9 | It is easier to read a line of text on a page in a book than on the screen. | O SA | O A | O D | O SD | O NS |
| Q10 | Computers can help me improve my understanding of mathematics. | O SA | O A | O D | O SD | O NS |
| Q11 | Computers are valuable tools for learning. | O SA | O A | O D | O SD | O NS |
| Q12 | The world would be better off if computers have never been invented. | O SA | O A | O D | O SD | O NS |
| Q13 | Learning mathematics using CAI is quicker and more efficient. | O SA | O A | O D | O SD | O NS |
| Q14 | Learning mathematics through CAI lacks the sense of presence that a human tutor provides. | O SA | O A | O D | O SD | O NS |
| Q15 | I would rather attend face-to-face tutorials with a human tutor than go through CAI. | O SA | O A | O D | O SD | O NS |
| Q16 | More IDCE courses should be taught through CAI. | O SA | O A | O D | O SD | O NS |
| Q17 | Learning mathematics through CAI is much better than learning it from course booklets. | O SA | O A | O D | O SD | O NS |
| Q18 | I joined CAI classes in mathematics 2 out of curiosity rather than because I think it is better than face-to-face tutorials. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 1

| | | | | | | |
|---|---|---|---|---|---|---|
| Q19 | I joined CAI classes because it was a chance to use and handle computers and not really to learn mathematics. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q20 | CAI can be a very useful way of learning mathematics if it is properly applied. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q21 | The time is right for computer applications like CAI in Papua New Guinea. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q22 | CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorials. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q23 | CAI cannot work in PNG because Papua New Guineans lack computer skills. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q24 | Learning mathematics through the medium of CAI is necessary. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q25 | CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q26 | CAI is better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |
| Q27 | Learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | ◯ SA | ◯ A | ◯ D | ◯ SD | ◯ NS |

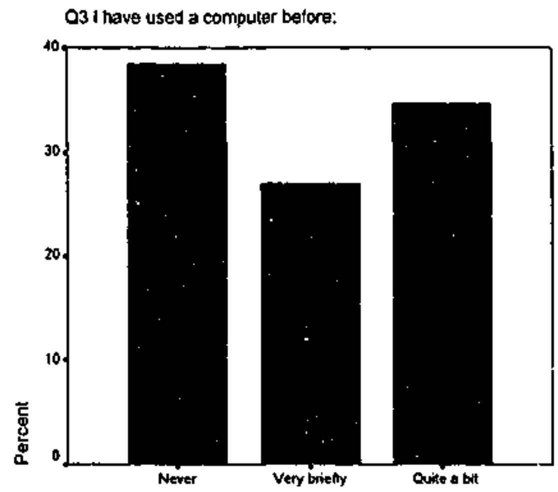
# Computer Attitudes Survey Questionnaire 1

| | | | | | | |
|---|---|---|---|---|---|---|
| Q28 | What's the big deal ! CAI, books or other modes of learning mathematics, they are all the same. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q29 | CAI is invented by people who are only interested in developing a commercial product. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q30 | If I had a computer I would definitely use CAI to study mathematics 2. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q31 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through these mediums. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q32 | I can learn mathematics better from a book in front of me than from a computer screen. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q33 | CAI is more effective in mediating learning in mathematics 2 than course booklets. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q34 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q35 | I would like to learn how to use the computer more effectively. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q36 | CAI is less effective in mediating learning in mathematics 2 than course booklets. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q37 | Even if I had a computer I would still prefer books and face to face tutorials to study any mathematics course including mathematics 2. | O SA | O A | O D | O SD | O NS |

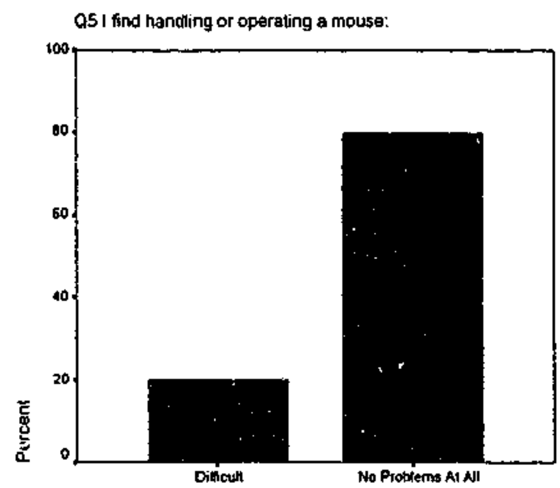
# Appendix P6: CSQ1 Frequency Summary Tables – Pilot Study

## Section A



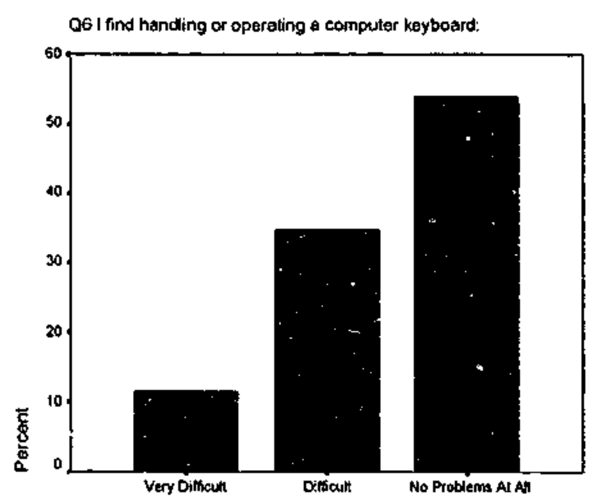

**Q3 I have used a computer before.**

| | Freq | Per | Cumul Per |
|---|---|---|---|
| Never | 10 | 38.5 | 38.5 |
| Very briefly | 7 | 26.9 | 65.4 |
| Quite a bit | 9 | 34.6 | 100.0 |
| Total | 26 | 100.0 | |




**Q5 I find handling or operating a mouse;**

| | Frequency | Percent |
|---|---|---|
| Difficult | 5 | 19.2 |
| No Problems At All | 20 | 76.9 |
| Total | 25 | 96.2 |
| Missing | 1 | 3.8 |
| Total | 26 | 100.0 |

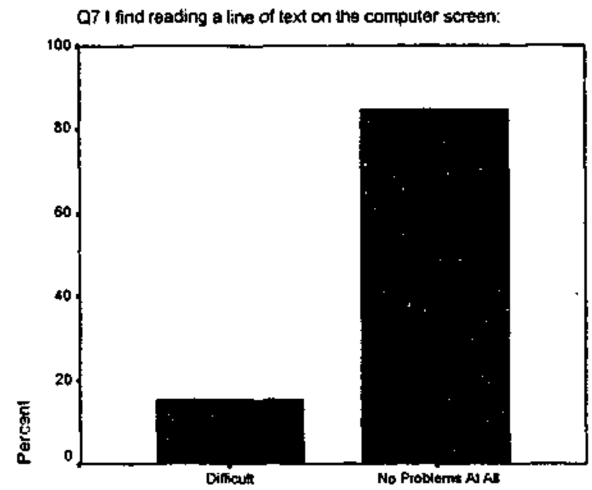



**Q6 I find handling or operating a computer keyboard;**

| | Freq | Per |
|---|---|---|
| Very Difficult | 3 | 11.5 |
| Difficult | 9 | 34.6 |
| No Problems At All | 14 | 53.8 |
| Total | 26 | 100.0 |

Q7 I find reading a line of text on the computer screen;

| | Freq | Per |
|---|---|---|
| Difficult | 4 | 15.4 |
| No Problems At All | 22 | 84.6 |
| Total | 26 | 100.0 |




## Appendix P7: Reliability Analysis of the CSQ1 Overall Likert Scale – Pilot Study

### Cronbach's Alpha

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Alpha if Item Deleted |
|---|---|---|---|---|
| Q9 | 100.0000 | 97.6800 | .3818 | .7821 |
| Q10 | 99.5769 | 97.2938 | .5128 | .7790 |
| Q11 | 100.0385 | 97.3185 | .2479 | .7886 |
| Q12 | 100.1923 | 93.1215 | .5803 | .7720 |
| Q13 | 101.2692 | 94.8446 | .3013 | .7864 |
| Q14 | 100.6538 | 94.9554 | .4522 | .7779 |
| Q15 | 100.0769 | 89.6738 | .6450 | .7658 |
| Q16 | 100.4615 | 96.0985 | .3581 | .7823 |
| Q18 | 101.4615 | 107.2985 | -.1867 | .8115 |
| Q19 | 99.6923 | 97.5015 | .4085 | .7813 |
| Q20 | 100.0000 | 99.9200 | .1738 | .7913 |
| Q21 | 100.6923 | 89.3415 | .6302 | .7660 |
| Q22 | 100.5000 | 95.7800 | .2872 | .7868 |
| Q23 | 99.9615 | 100.9185 | .3094 | .7866 |
| Q24 | 99.6923 | 93.9815 | .5368 | .7742 |
| Q25 | 100.6923 | 93.1815 | .5022 | .7746 |
| Q26 | 100.0000 | 94.0800 | .5479 | .7740 |
| Q27 | 101.3846 | 97.6062 | .2585 | .7876 |
| Q28 | 100.3077 | 102.6215 | .0191 | .8002 |
| Q29 | 99.6154 | 101.8462 | .1167 | .7923 |
| Q30 | 99.8077 | 100.7215 | .2181 | .7885 |
| Q31 | 100.6538 | 96.3954 | .4488 | .7792 |
| Q32 | 100.6923 | 102.7815 | .0227 | .7986 |
| Q33 | 99.5385 | 102.6585 | .1304 | .7909 |
| Q34 | 99.1923 | 103.7615 | .1040 | .7915 |
| Q35 | 100.6923 | 99.0215 | .1718 | .7928 |
| Q37 | 101.1538 | 89.8154 | .5027 | .7728 |

Reliability Coefficients
N of Cases = 26.0 N of Items = 27
Alpha = .7910

# Appendix P8: Summary Statistics for the CSQ1 Data – Pilot Study

**CSQ1 Summary Statistics**

| | N | Mean | Median | Std. Dev. | Skew ness | Std. Err. of Skewness | Kurtosis | Std. Err. of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Q7 | 26 | 3.42 | 4.00 | 1.24 | -.220 | .456 | -1.207 | .887 |
| Q8 | 26 | 4.15 | 4.00 | .78 | -.287 | .456 | -1.279 | .887 |
| Q9 | 26 | 4.58 | 5.00 | .64 | -1.286 | .456 | .669 | .887 |
| Q10 | 26 | 4.12 | 4.50 | 1.14 | -1.287 | .456 | .982 | .887 |
| Q11 | 26 | 3.96 | 4.00 | .92 | -.258 | .456 | -1.073 | .887 |
| Q12 | 26 | 2.88 | 3.00 | 1.31 | .230 | .456 | -.932 | .887 |
| Q13 | 26 | 3.50 | 3.50 | .95 | .000 | .456 | -.783 | .887 |
| Q14 | 26 | 4.08 | 4.50 | 1.09 | -.761 | .456 | -.827 | .887 |
| Q15 | 26 | 3.69 | 4.00 | 1.01 | -.070 | .456 | -1.096 | .887 |
| Q16 | 26 | 2.69 | 2.50 | 1.12 | -.065 | .456 | -1.440 | .887 |
| Q18 | 26 | 4.46 | 5.00 | .76 | -1.633 | .456 | 3.132 | .887 |
| Q19 | 26 | 4.15 | 4.00 | .97 | -1.192 | .456 | .788 | .887 |
| Q20 | 26 | 3.46 | 4.00 | 1.14 | -.337 | .456 | -.725 | .887 |
| Q21 | 26 | 3.65 | 4.00 | 1.23 | -.803 | .456 | -.173 | .887 |
| Q22 | 26 | 4.19 | 4.00 | .49 | .486 | .456 | .615 | .887 |
| Q23 | 26 | 4.46 | 5.00 | .90 | -2.510 | .456 | 7.982 | .887 |
| Q24 | 26 | 3.46 | 4.00 | 1.03 | -.127 | .456 | -1.086 | .887 |
| Q25 | 26 | 4.15 | 4.00 | .88 | -.701 | .456 | -.348 | .887 |
| Q26 | 26 | 2.77 | 3.00 | 1.07 | .075 | .456 | -.650 | .887 |
| Q27 | 26 | 3.85 | 4.00 | 1.08 | -.896 | .456 | .492 | .887 |
| Q28 | 26 | 4.54 | 5.00 | .76 | -1.913 | .456 | 3.974 | .887 |
| Q29 | 26 | 4.35 | 4.00 | .69 | -.584 | .456 | -.650 | .887 |
| Q30 | 26 | 3.50 | 4.00 | .81 | -.242 | .456 | -.287 | .887 |
| Q31 | 26 | 3.46 | 3.00 | .99 | -.288 | .456 | .292 | .887 |
| Q32 | 26 | 4.62 | 5.00 | .50 | -.504 | .456 | -1.899 | .887 |
| Q33 | 26 | 4.96 | 5.00 | .20 | -5.099 | .456 | 26.000 | .887 |
| Q34 | 26 | 3.46 | 3.00 | 1.14 | -.161 | .456 | -.697 | .887 |
| Q35 | 26 | 3.00 | 3.00 | 1.33 | .000 | .456 | -1.098 | .887 |

# Computer Attitudes Survey Questionnaire 2

## Pilot Study

| | | | | | | |
|---|---|---|---|---|---|---|
| Q1 | I find handling or operating a mouse; | ○ Very difficult | ○ Difficult | ○ No problems at all | | |
| Q2 | I find handling or operating a computer keyboard; | ○ Very difficult | ○ Difficult | ○ No problems at all | | |
| Q3 | I find reading a line of text on the computer screen; | ○ Very difficult | ○ Difficult | ○ No problems at all | | |
| Q4 | Were the CAI lessons easy to use? | ○ Definitely not | ○ Yes | ○ Not really | ○ Yes, definitely | |
| Q5 | Were you happy with the amount of control you had over the CAI lessons? | ○ Definitely not | ○ Yes | ○ Not really | ○ Yes, definitely | |
| Q6 | Do you think you learn faster and better on computer? | ○ Definitely not | ○ Yes | ○ Not really | ○ Yes, definitely | |
| Q7 | It is easier to read a line of text on a page in a book than on the screen. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q8 | Computers have helped me improve my understanding of mathematics. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q9 | The CAI-based mathematics 2 course has helped me improve my understanding of the contents of the course. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q10 | Computers are valuable tools for learning. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q11 | The world would be better off if computers have never been invented. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q12 | Learning mathematics using CAI is quicker and more efficient. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q13 | I would take another mathematics course through CAI after this experience. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q14 | Learning mathematics through CAI lacks the sense of presence that a human tutor provides. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q15 | I would rather attend face-to-face tutorials with a human tutor than go through CAI again. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q16 | More IDCE courses should be taught through CAI. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q17 | Learning mathematics through CAI is much better than learning it from course booklets. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q18 | CAI can be a very useful way of learning mathematics if it is properly applied. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q19 | The time is right for computer applications like CAI in Papua New Guinea. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q20 | CAI as a mode of learning in distance education in PNG should be pursued more vigorously. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q21 | CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorial. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q22 | CAI cannot work in PNG because Papua New Guineans lack computer skills. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q23 | Learning mathematics through CAI is necessary. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q24 | CAI or any thing to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q25 | CAI is better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q26 | Learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q27 | What's the big deal ! CAI, books or other modes of learning mathematics, they are all the same. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q28 | I would like learn how to use the computer more effectively. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |
| Q29 | Computers can really make one's life more difficult. | ○ SA | ○ A | ○ NS | ○ D | ○ SD |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q30 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through these mediums. | O SA | O A | O NS | O D | O SD |
| Q31 | I can learn mathematics better from a book in front of me than from a computer screen. | O SA | O A | O NS | O D | O SD |
| Q32 | CAI is more effective in mediating learning in mathematics 2 than course booklets. | O SA | O A | O NS | O D | O SD |
| Q33 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | O SA | O A | O NS | O D | O SD |
| Q34 | I would like to learn how to use the computer more effectively | O SA | O A | O NS | O D | O SD |
| Q35 | CAI is less effective in mediating learning in mathematics 2 than course booklets. | O SA | O A | O NS | O D | O SD |
| Q36 | Mathematics comes alive when taught through CAI. | O SA | O A | O NS | O D | O SD |
| Q37 | I can see relationships and concepts in mathematics through the medium of CAI that I couldn't see before using books only. | O SA | O A | O NS | O D | O SD |
| Q38 | Concepts in mathematics that I found difficult before are clearer when presented through CAI. | O SA | O A | O NS | O D | O SD |

# Computer Attitudes Survey Questionnaire 2

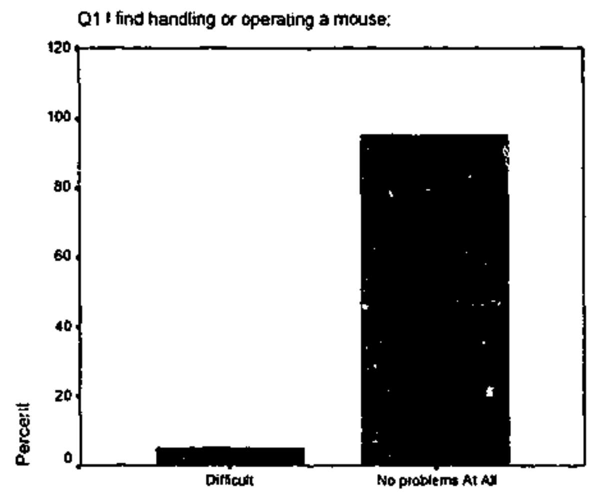
| | | | | | | |
|---|---|---|---|---|---|---|
| Q39 | The color, graphics and animation in CAI has helped me understand mathematical concepts better. | O SA | O A | O NS | O D | O SD |
| Q40 | The navigation capabilities provided in the CAI software is clear and logical that I know exactly where I am in the CAI mediated mathematics lessons. | O SA | O A | O NS | O D | O SD |
| Q41 | The color, graphics and animation in CAI is distracting for me making CAI less effective as a learning tool. | O SA | O A | O NS | O D | O SD |
| Q42 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | O SA | O A | O NS | O D | O SD |

# Appendix P10: CSQ2 Frequency Summary Tables – Pilot Study

## SECTION A

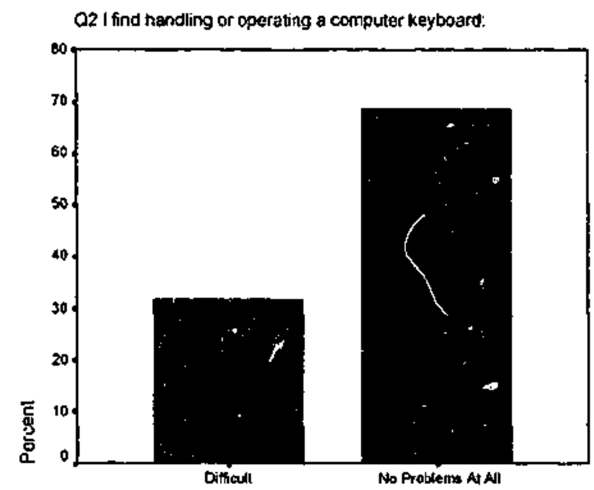
**Q1 I find handling or operating a mouse;**

| | Freq | Per |
|---|---|---|
| Difficult | 1 | 5.0 |
| No problems At All | 19 | 95.0 |
| Total | 20 | 100.0 |



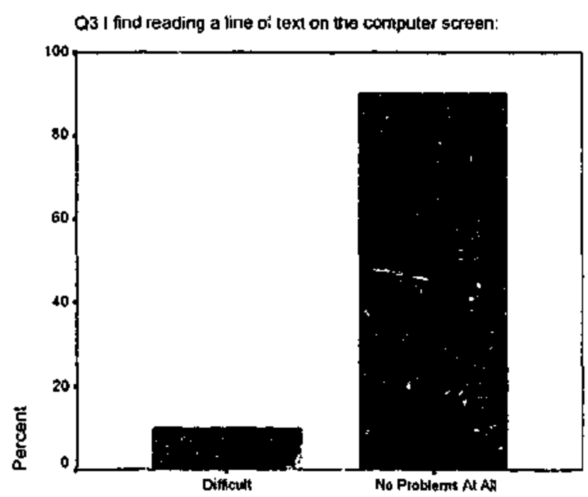

**Q2 I find handling or operating a computer keyboard;**

| | Freq | Per |
|---|---|---|
| Difficult | 6 | 30.0 |
| No Problems At All | 13 | 65.0 |
| Total | 19 | 95.0 |
| Missing | 1 | 5.0 |
| Total | 20 | 100.0 |



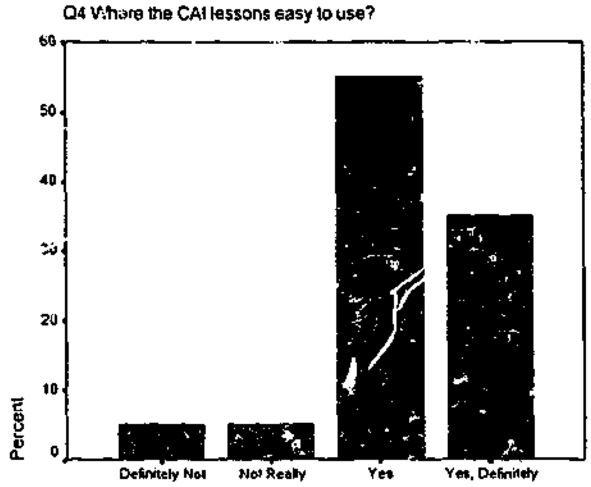

**Q3 I find reading a line of text on the computer screen;**

| | Freq | Per |
|---|---|---|
| Difficult | 2 | 10.0 |
| No Problems At All | 18 | 90.0 |
| Total | 20 | 100.0 |



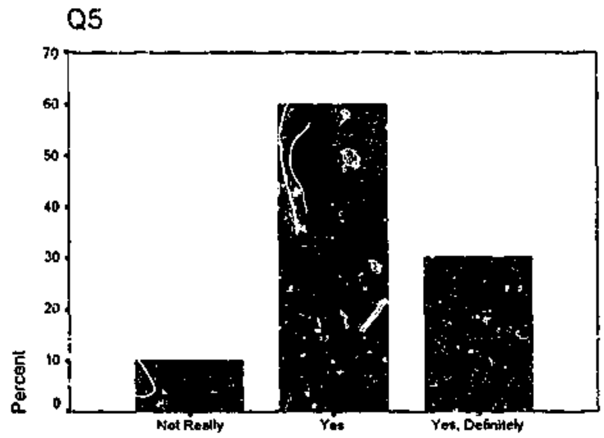
**Q4 Were the CAI lessons easy to use?**

| | Freq | Per |
|---|---|---|
| Definitely Not | 1 | 5.0 |
| Not Really | 1 | 5.0 |
| Yes | 11 | 55.0 |
| Yes, Definitely | 7 | 35.0 |
| Total | 20 | 100.0 |




**Q5 Were you happy with the amount of control you had over the CAI lessons?**

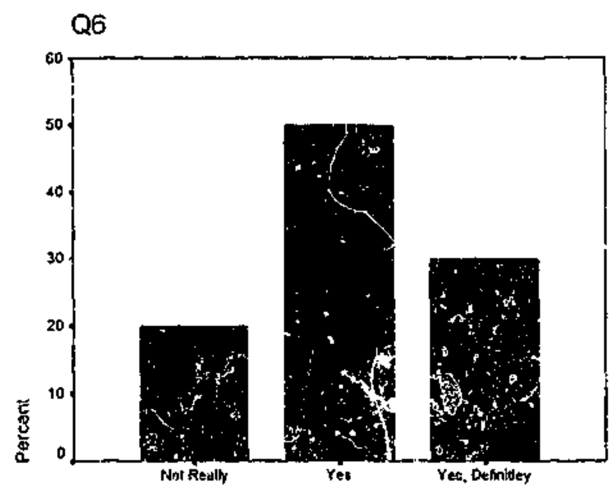
| | Freq | Per |
|---|---|---|
| Not Really | 2 | 10.0 |
| Yes | 12 | 60.0 |
| Yes, Definitely | 6 | 30.0 |
| Total | 20 | 100.0 |




Question 5

**Q6 Do you think you learn faster and better on the computer?**

| | Freq | Per |
|---|---|---|
| Not Really | 4 | 20.0 |
| Yes | 10 | 50.0 |
| Yes, Definitley | 6 | 30.0 |
| Total | 20 | 100.0 |



# Appendix P11: Reliability Analysis of the CSQ2 Overall Likert Scale – Pilot Study

## Cronbach's Alpha

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Alpha if Item Deleted |
|---|---|---|---|---|
| Q7 | 143.2632 | 174.9825 | .2997 | .8812 |
| Q8 | 142.4211 | 171.3684 | .8429 | .8744 |
| Q9 | 142.2632 | 170.2047 | .7169 | .8744 |
| Q10 | 141.9474 | 175.7193 | .5940 | .8779 |
| Q11 | 142.8421 | 183.8070 | -.0580 | .8929 |
| Q12 | 142.3158 | 167.8947 | .7731 | .8728 |
| Q13 | 142.3158 | 176.6725 | .3130 | .8806 |
| Q14 | 144.0000 | 169.7778 | .4063 | .8794 |
| Q15 | 143.3684 | 174.1345 | .2806 | .8822 |
| Q16 | 142.3684 | 170.8012 | .5224 | .8767 |
| Q17 | 142.6316 | 168.5789 | .5349 | .8761 |
| Q18 | 141.9474 | 182.0526 | .0921 | .8831 |
| Q19 | 142.0000 | 177.8889 | .4034 | .8798 |
| Q20 | 142.2105 | 180.1754 | .2229 | .8818 |
| Q21 | 143.2105 | 164.1754 | .5477 | .8757 |
| Q22 | 142.6316 | 170.4678 | .5307 | .8765 |
| Q23 | 142.1053 | 171.9883 | .8336 | .8748 |
| Q24 | 142.1579 | 177.3626 | .3028 | .8807 |
| Q25 | 143.0000 | 166.5556 | .4939 | .8772 |
| Q26 | 142.1579 | 170.5848 | .6090 | .8755 |
| Q27 | 144.3158 | 187.7836 | -.1825 | .8931 |
| Q28 | 141.8947 | 178.5439 | .3903 | .8801 |
| Q29 | 142.1579 | 181.8070 | .0780 | .8838 |
| Q30 | 142.4737 | 170.9298 | .3858 | .8798 |
| Q31 | 143.0000 | 169.1111 | .5412 | .8761 |
| Q32 | 143.0000 | 173.6667 | .2908 | .8821 |
| Q33 | 142.0526 | 179.2749 | .2897 | .8810 |
| Q34 | 141.8421 | 180.0292 | .2903 | .8812 |
| Q35 | 143.0000 | 171.8889 | .3979 | .8792 |
| Q36 | 142.6316 | 169.6901 | .6809 | .8745 |
| Q37 | 142.6842 | 178.5614 | .1847 | .8831 |
| Q38 | 142.4211 | 169.3684 | .7320 | .8739 |
| Q39 | 142.0526 | 178.4971 | .3477 | .8804 |
| Q40 | 142.1053 | 173.7661 | .5783 | .8770 |
| Q41 | 142.3158 | 173.2281 | .6458 | .8763 |
| Q42 | 143.0000 | 162.6667 | .5763 | .8749 |

\-

Reliability Coefficients

N of Cases = 19.0 N of Items = 36

Alpha = .8823

# Appendix P12: Summary Statistics for the CSQ2 Data – Pilot Study

**CSQ2 Summary Statistics**

| | N | Mean | Median | Std. Dev. | Skew ness | Std. Err. of Skewness | Kurtosis | Std. Err. of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Q7 | 20 | 3.35 | 4.00 | .93 | -.377 | .512 | -1.077 | .992 |
| Q8 | 20 | 4.15 | 4.00 | .59 | -.004 | .512 | .178 | .992 |
| Q9 | 20 | 4.30 | 4.00 | .73 | -.553 | .512 | -.834 | .992 |
| Q10 | 20 | 4.70 | 5.00 | .47 | -.945 | .512 | -1.242 | .992 |
| Q11 | 20 | 3.85 | 4.00 | 1.31 | -.946 | .512 | .173 | .992 |
| Q12 | 20 | 4.25 | 4.00 | .79 | -1.218 | .512 | 2.248 | .992 |
| Q13 | 20 | 4.35 | 4.50 | .75 | -.697 | .512 | -.762 | .992 |
| Q14 | 20 | 2.70 | 2.00 | 1.17 | .654 | .512 | -.369 | .992 |
| Q15 | 20 | 3.25 | 3.00 | 1.07 | -.269 | .512 | -.431 | .992 |
| Q16 | 20 | 4.20 | 4.00 | .89 | -.922 | .512 | .224 | .992 |
| Q17 | 20 | 3.95 | 4.00 | 1.00 | -.596 | .512 | -.585 | .992 |
| Q18 | 20 | 4.70 | 5.00 | .47 | -.945 | .512 | -1.242 | .992 |
| Q19 | 20 | 4.65 | 5.00 | .49 | -.681 | .512 | -1.719 | .992 |
| Q20 | 20 | 4.45 | 4.00 | .51 | .218 | .512 | -2.183 | .992 |
| Q21 | 20 | 3.45 | 4.00 | 1.23 | -.432 | .512 | -.987 | .992 |
| Q22 | 20 | 4.00 | 4.00 | .86 | -.555 | .512 | -.080 | .992 |
| Q23 | 19 | 4.53 | 5.00 | .51 | -.115 | .524 | -2.235 | 1.014 |
| Q24 | 20 | 4.35 | 5.00 | .88 | -1.321 | .512 | 1.289 | .992 |
| Q25 | 20 | 3.65 | 4.00 | 1.18 | -.717 | .512 | -.253 | .992 |
| Q26 | 20 | 4.50 | 5.00 | .76 | -1.991 | .512 | 5.136 | .992 |
| Q27 | 20 | 2.35 | 2.00 | 1.09 | .292 | .512 | -1.125 | .992 |
| Q28 | 20 | 4.75 | 5.00 | .44 | -1.251 | .512 | -.497 | .992 |
| Q29 | 20 | 4.45 | 4.50 | .60 | -.583 | .512 | -.459 | .992 |
| Q30 | 20 | 4.15 | 4.00 | 1.09 | -1.683 | .512 | 2.937 | .992 |
| Q31 | 20 | 3.60 | 4.00 | .94 | -.321 | .512 | -.577 | .992 |
| Q32 | 20 | 3.60 | 4.00 | 1.10 | -.149 | .512 | -1.220 | .992 |
| Q33 | 20 | 4.60 | 5.00 | .50 | -.442 | .512 | -2.018 | .992 |
| Q34 | 20 | 4.80 | 5.00 | .41 | -1.624 | .512 | .699 | .992 |
| Q35 | 20 | 3.65 | 4.00 | .99 | -1.010 | .512 | 1.594 | .992 |
| Q36 | 20 | 3.95 | 4.00 | .76 | -.716 | .512 | 1.195 | .992 |
| Q37 | 20 | 3.95 | 4.00 | .83 | -1.149 | .512 | 1.840 | .992 |
| Q38 | 20 | 4.20 | 4.00 | .70 | -1.333 | .512 | 4.442 | .992 |
| Q39 | 20 | 4.60 | 5.00 | .50 | -.442 | .512 | -2.018 | .992 |
| Q40 | 20 | 4.50 | 5.00 | .61 | -.785 | .512 | -.213 | .992 |
| Q41 | 20 | 4.35 | 4.00 | .59 | -.212 | .512 | -.552 | .992 |
| Q42 | 20 | 3.65 | 4.00 | 1.27 | -.977 | .512 | .109 | .992 |

**Appendix P13: Posttest (Pilot Version)**

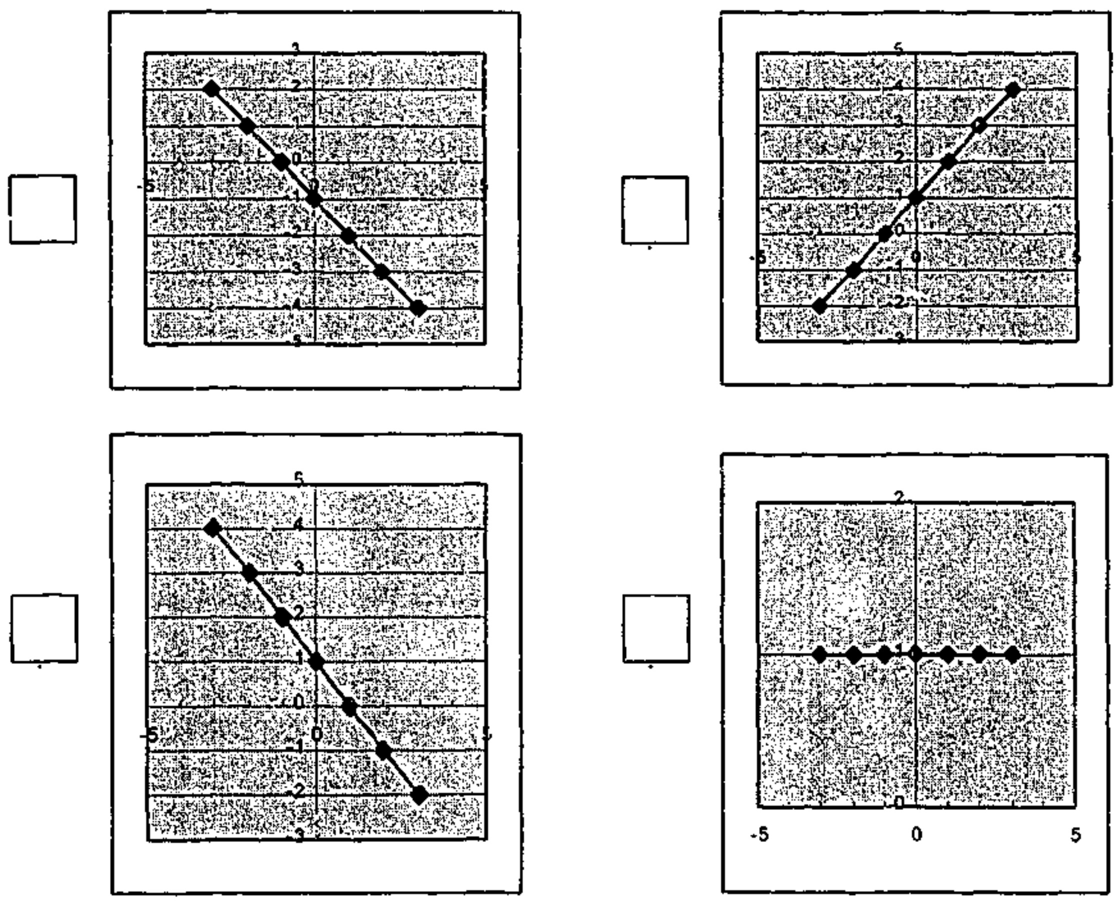
In each question circle the letter that corresponds to the correct answer.
Every question is worth a mark each.

**Please Attempt All Questions.**

1. In the gradient-intercept form of the straight line equation **y = ax + b**, which of the letters in the equation represents the slope?

   A. **y** B. **a** C. **ax** D. **b**

2. Which of the graphs below is that of the equation y = 1 – x



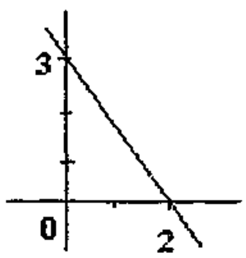

3. The coordinates of the point where the straight line **y = x + 3** cuts the **x - axis** is given by the points;

   A. (3, 0) B. (0, 3) C. (0, -3) D. (-3, 0)

4. Which of the following points is not on the line **y = 5 – 4x** ?

A. (-3, 17) B. (-1, 8) C. (0, 5) D. (3.5, - 9)

5. The equation of the straight line in the diagram below is given by




A. $y = -2x + 3$

B. $y = -\frac{3}{2}x + 3$

C. $y = \frac{3}{2}x + 3$

D. It cannot be worked out because insuffcient information is given in the diagram.

6. Which of the statements below is true for the parallel lines

$y = mx + a$ ........... (1)
$y = mx + b$ ........... (2)
$y = mx + c$ ........... (3)

and $a \neq b \neq c$

A. They intersect at the same point
B. They cross the y-axis at the same point
C. They cross the x-axis at the same point
D. They do not intersect at any point

7. Hooke's Law given by **E = 2W** describes the elongation in a spring due to weight applied to it.

   If **E** is the elongation in centimetres and **W** is the weight in kilograms, then a weight of $\frac{1}{2}$ kilogram would cause an elongation of

   A. 4 cm    B. 2 cm    C. 1 cm    D. $\frac{1}{4}$ cm

8. If a line is said to have a slope or gradient that is infinite ( $\infty$ ), which of the following statements is **not** true?

A. It is a horizontal line

B. It is a vertical line

C. It's equation is of the form $x = c$ where c is some constant number

D. The expression $x_2 - x_1$ equals **0** in the gradient formula $m = \dfrac{y_2 - y_1}{x_2 - x_1}$

9. A line passing through the points (-4, 3) and (-1, -1) has slope equal to

   A. $\frac{4}{5}$    B. $\frac{3}{4}$    C. $-\frac{4}{3}$    D. $\frac{4}{3}$

**The following information refer to questions (10), (11) and (12).**

The mid-point of $(x_1, y_1)$ and $(x_2, y_2)$ is given by $\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$.
A line $l$ passes through the mid-point of (2, 5) and (4, 7) and the midpoint of (-4, 3) and (-2, -1).

10. Two points which are definitely on the line $l$ are

   A. (2, 5) and (4, 7)    B. (-4, 3) and (-2, -1)

   C. (3, 6) and (-3, 1)    D. (-1, 4) and (1, 3)

11. The gradient of the line $l$ is

A. $\infty$ B. $\frac{3}{2}$ C. $-\frac{5}{6}$ D. $\frac{5}{6}$

12. The equation of line $l$ is

A. $x = 3$ B. $3x - 2y + 7 = 0$

C. $5x + 6y - 21 = 0$ D. $5x - 6y + 21 = 0$

13. The equation of a line which passes through the midpoint of (0, 4) and (6, 6) and is parallel to the line $3y + x = 6$ is;

A. $y = -\frac{1}{3}x + 6$ B. $y = -\frac{1}{3}x + 8$

C. $y = -\frac{1}{3}x + 2$ D. $y = -3x - 12$

14. Which of the following statements about perpendicular lines are true.

(i) Any line with gradient 0 is perpendicular to any vertical line.
(ii) A line with gradient 0, passing through the point (2, 3) will also pass through the point (3, 2).
(iii) If two lines with gradients $\mathbf{m_1}$ and $\mathbf{m_2}$ are perpendicular then the condition $\mathbf{m_1 \times m_2 = -1}$ holds.
(iv) The gradient of a line **h** is $-\frac{1}{2}$ therefore the gradient of a line perpendicular to **h** is 2.

A. (i), (ii) and (iii) only B. (i), (iii) and (iv) only

C. (ii), (iii) and (iv) only D. All of them

15. The lines $2x + 3y + 7 = 0$ and $5x - y - 8 = 0$ intersect at the point:

A. (2, 3) B. (-1, 3) C. (1, -3) D. (5, -1)

16. Raka's age is 7 years less than twice Kila's age. Together their ages add to 8 years. If **x** represents Raka's age and **y** represents Kila's;

Which of the following statements are true?

(I) $x + y = 8$
(II) $x = 7 - 2y$
(III) $x = 2y - 7$
(IV) Kila is younger than Raka
(V) Kila is older than Raka

A. (I), (II) and (IV) only
B. (I), (III) and (IV) only
C. (I), (II) and (V) only
D. (I), (III) and (V) only

17. Given that **b** = $\sqrt{x^2 - a^2}$ , then **a** =

A. $x^2 - b^2$ B. $\pm\sqrt{x^2 - b}$

C. $\pm\sqrt{x^2 - b^2}$ D. $\pm\sqrt{x - b}$

18. If **x = 5** and **y = -2** then the value of the algebraic expression

$xy^2 - x^2y$ is:

A. -30 B. 70 C. 200 D. 210

( 2 marks )

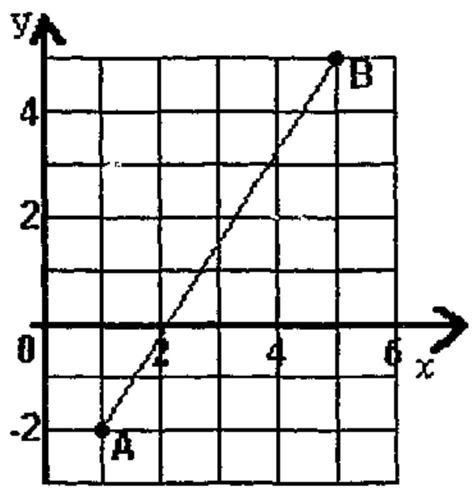
19. The formula for calculating simple interest is $\mathbf{I} = \frac{\mathbf{PRN}}{\mathbf{100}}$ , where

**P** = Principal sum invested
**N** = Number of years the principal sum is invested
**R** = Percentage Rate at which the principal sum is invested

The percentage rate at which a principal sum of **K 540.00** is invested for $3\frac{1}{2}$ years earning an interest of **K 113.40** is

A. 4 %     B. 5%     C. 6%     D. 7%

The information in the diagram below refers to **questions 20** and **21** .




20. The coordinates of the two opposite vertices of a rectangle are (1, -2) and (5, 5) as shown in the diagram above.

What is the length of the diagonal **AB** of the rectangle to the nearest whole number?

A. 5     B. 7     C. 8     D. 9

21. The two other vertices of the rectangle are

A. (1, 4) and (5, -1)     B. (2, 5) and (4, -2)

C. (0, 5) and (6, -2)     D. (1, 5) and (5, -2)

22. $W = \frac{1}{2}mv^2 + mgh$. If $v = 6$, $m = 2$, $W = 1996$ and $g = 980$, then the value of h is;

A. 1 B. 2 C. 3 D. 4

23. Given that $A = P\left(1 + \frac{r}{100}\right)$, then r =

A. $100\left(\frac{A+P}{P}\right)$ B. $100\left(\frac{A-P}{P}\right)$

C. $100\frac{A}{P} - 1$ D. $100(AP - 1)$

24. When expanded $(x - 2)(x + 3) =$

A. $x^2 - x - 6$ B. $x^2 + x - 6$

C. $x^2 - x + 6$ D. $x^2 + 5x - 6$

25. When factorized $3x^2 + x - 10 =$

A. $(3x - 10)(x + 1)$ B. $(3x + 10)(x - 1)$

C. $(3x + 5)(x - 2)$ D. $(3x - 5)(x + 2)$

26. The lowest Common denominator of the algebraic expression

$\frac{7x}{2x^2 - 18y^2} - \frac{3}{5x + 15y}$ in simplest factor form is

A. $10(x^2 - 9y^2)(x + 3y)$ B. $10(x^2 - 9y^2)$

C. $10(x + 3y)(x - 3y)$ D. $10(x + 3y)$

27. The algebraic fraction $\dfrac{a^2 + 2ab + b^2}{a^2 - b^2}$ in its simplest form is

A. $\dfrac{1+2ab+1}{1-1}$

B. $\dfrac{(a+b)^2}{(a-b)^2}$

D. $\dfrac{a+b}{a-b}$

D. $\dfrac{a+b}{a+b}$

28. Look at the following statements about various aspects of parabolas and decide Which statements are true and which are not.

I. The vertex of a parabola is the point around which the graph curves
II. The line of symmetry goes through the vertex
III. All parabolas of the form $y = ax^2 + bx + c$ have strictly 2 solutions
IV. The direction of curve or binding of a parabola $y = ax^2 + bx + c$ is determined by whether $a$ is positive or negative
V. The quadratic equation $x^2 + 1$ has at least one real solution

The true statements are;

A. I, II and III only

B. I, II and V only

C. I, II and IV only

C. All of them

29. Look at the following algebraic expressions and their simplified forms. Which of the following expressions are matched with their correct simplest forms.

(i) $\dfrac{x^2 - x - 6}{4xy} \div \dfrac{x^2 - 9}{2x^2y} = \dfrac{x^2 + 2x}{2x + 6}$

(ii) $\dfrac{15ab}{8} \times \dfrac{16}{3a^2b} = \dfrac{10}{a}$

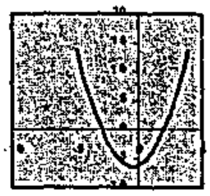
(iii) $\dfrac{x^2 + xy}{2xy} = \dfrac{x + y}{2y}$

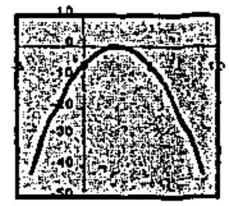
(iv) $\dfrac{5}{2x} + \dfrac{3}{4x} = \dfrac{13}{4x}$

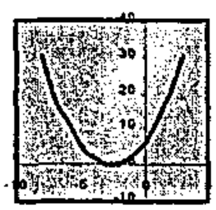
A. (i) and (ii) only B. (ii) only

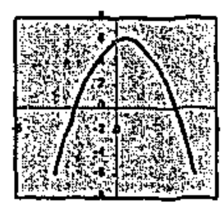
C. (ii), (iii) and (iv) only D. All of them

30. Which graph below is most likely showing the parabola $y = x^2 + x - 6$ .

☐ 

☐ 

☐ 

☐ 

31. What are the two binomial factors of the quadratic equation $\mathbf{x^2 - x - 20 = 0}$

A. (x - 10) and (x + 2) B. (x + 10) and (x − 2)

C. (x − 5) and (x + 4) D. (x + 5) and (x − 4)

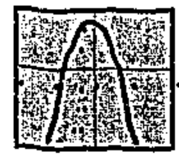
32. At which point does the linear equation $2x + y + 2 = 0$ meet the parabola $y = 2x^2 - 6x$ ?

A. (1, -4) B. (1, 4) C. (1, 0) D. None of these

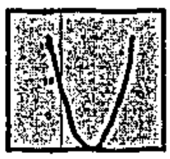
The graphs below refer to questions 33 and 34

I

II



III



IV

V

VI

33. The general quadratic equation is given by $y = ax^2 + bx + c$.
Which of the graphs above show the situation where $a < 0$

A. I, IV and V only B. II and III only

C. III, IV and VI only D. II, III and VI only

34. Which graphs show parabolas with no real roots ?

A. I and VI only B. II and IV only

C. III and V only D. VI only

35. A rectangular piece of sheet metal is 3m longer than it is wide. The area of the piece of sheet metal is $28 \text{ m}^2$.

What are its dimensions?

A. Length = 6 m, Width = 3 m **B.** Length = 7 m, Width = 3 m

C. Length = 7 m, Width = 4 m **D.** Length = 10 m, Width = 7 m

## Appendix P14: Facility and Difficulty Analysis Indices for the Posttest – Pilot Study

**Appendix P14: Facility and Difficulty Indices for the Posttest - Pilot Study**

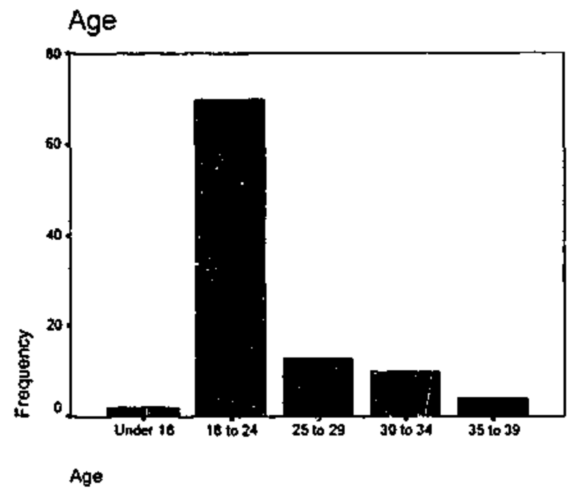
| Student | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Top 27 % | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 2 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 4 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| 7 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 8 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| Tcorrect | 8 | 6 | 7 | 8 | 7 | 9 | 8 | 4 | 9 | 9 | 7 | 7 | 7 | 8 | 6 | 6 | 7 | 7 | 9 | 6 | 4 | 7 | 4 | 8 | 9 | 5 | 5 | 6 | 6 | 5 | 8 | 3 | 2 | 4 | 8 |
| % Correct | 0.89 | 0.67 | 0.78 | 0.89 | 0.78 | 1 | 0.89 | 0.44 | 1 | 1 | 0.78 | 0.78 | 0.78 | 0.89 | 0.67 | 0.67 | 0.78 | 0.78 | 1 | 0.67 | 0.44 | 0.78 | 0.44 | 0.89 | 1 | 0.56 | 0.56 | 0.67 | 0.67 | 0.56 | 0.89 | 0.33 | 0.22 | 0.44 | 0.89 |
| Bottom 27 % | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 26 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 27 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 28 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 29 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 30 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 33 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tcorrect | 2 | 2 | 3 | 2 | 2 | 4 | 8 | 0 | 8 | 8 | 1 | 0 | 2 | 1 | 3 | 4 | 3 | 4 | 2 | 1 | 1 | 3 | 2 | 3 | 4 | 5 | 1 | 2 | 5 | 0 | 3 | 3 | 0 | 1 | 4 |
| % Correct | 0.22 | 0.22 | 0.33 | 0.22 | 0.22 | 0.44 | 0.89 | 0 | 0.89 | 0.89 | 0.11 | 0 | 0.22 | 0.11 | 0.33 | 0.44 | 0.33 | 0.44 | 0.22 | 0.11 | 0.11 | 0.33 | 0.22 | 0.33 | 0.44 | 0.56 | 0.11 | 0.22 | 0.56 | 0 | 0.33 | 0.33 | 0 | 0.11 | 0.44 |
| DI | 0.67 | 0.44 | 0.44 | 0.67 | 0.56 | 0.56 | 0 | 0.44 | 0.11 | 0.11 | 0.67 | 0.78 | 0.56 | 0.78 | 0.33 | 0.22 | 0.44 | 0.33 | 0.78 | 0.56 | 0.33 | 0.44 | 0.22 | 0.56 | 0.56 | 0 | 0.44 | 0.44 | 0.11 | 0.56 | 0.56 | 0 | 0.22 | 0.33 | 0.44 |

# Main Study Appendices

## Appendix M1: Population Characteristics Summary

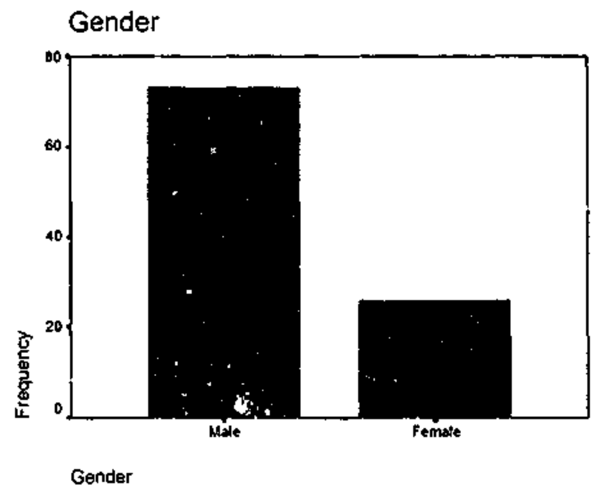
**Age**

| | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Under 18 | 2 | 2.0 | 2.0 |
| 18 to 24 | 70 | 70.7 | 72.7 |
| 25 to 29 | 13 | 13.1 | 85.9 |
| 30 to 34 | 10 | 10.1 | 96.0 |
| 35 to 39 | 4 | 4.0 | 100.0 |
| Total | 99 | 100.0 | |



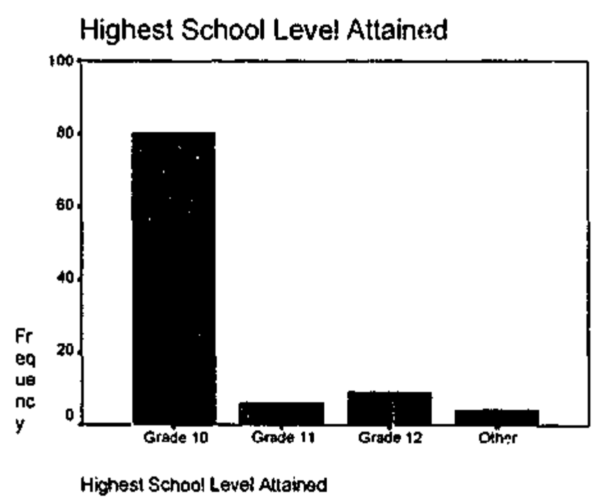

**Gender**

| | Frequency | Percent |
|---|---|---|
| Male | 73 | 73.7 |
| Female | 26 | 26.3 |
| Total | 99 | 100.0 |




**Highest School Level Attained**

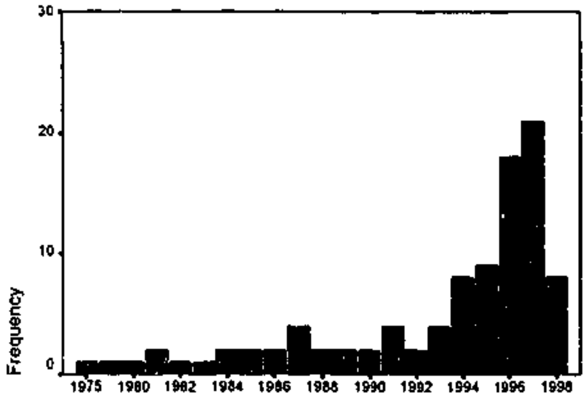
| | Frequency | Percent |
|---|---|---|
| Grade 10 | 80 | 80.8 |
| Grade 11 | 6 | 6.1 |
| Grade 12 | 9 | 9.1 |
| Other | 4 | 4.0 |
| Total | 99 | 100.0 |



In which year did you complete Grade 10 ?

| | Frequency | Percent |
|---|---|---|
| 1975 | 1 | 1.0 |
| 1976 | 1 | 1.0 |
| 1980 | 1 | 1.0 |
| 1981 | 2 | 2.0 |
| 1982 | 1 | 1.0 |
| 1983 | 1 | 1.0 |
| 1984 | 2 | 2.0 |
| 1985 | 2 | 2.0 |
| 1986 | 2 | 2.0 |
| 1987 | 4 | 4.0 |
| 1988 | 2 | 2.0 |
| 1989 | 2 | 2.0 |
| 1990 | 2 | 2.0 |
| 1991 | 4 | 4.0 |
| 1992 | 2 | 2.0 |
| 1993 | 4 | 4.0 |
| 1994 | 8 | 8.1 |
| 1995 | 9 | 9.1 |
| 1996 | 18 | 18.2 |
| 1997 | 21 | 21.2 |
| 1998 | 8 | 8.1 |
| Total | 97 | 98.0 |
| Missing | 2 | 2.0 |
| Total | 99 | 100.0 |

In which year did you complete grade 10 ?

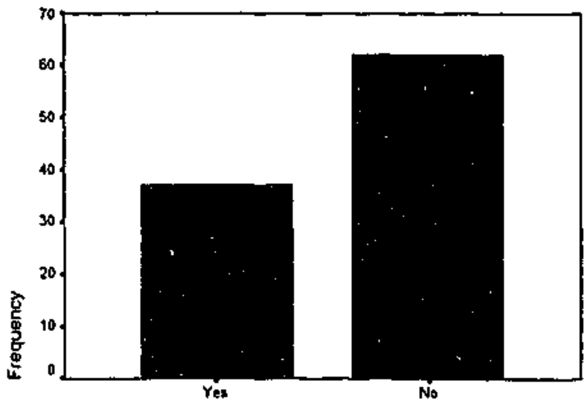



Year in which Grade 10 done

Have you attended a tertiary Educational Institution since finishing school ?

| | Frequency | Percent |
|---|---|---|
| Yes | 37 | 37.4 |
| No | 62 | 62.6 |
| Total | 99 | 100.0 |

Attended Tertiary Education ?

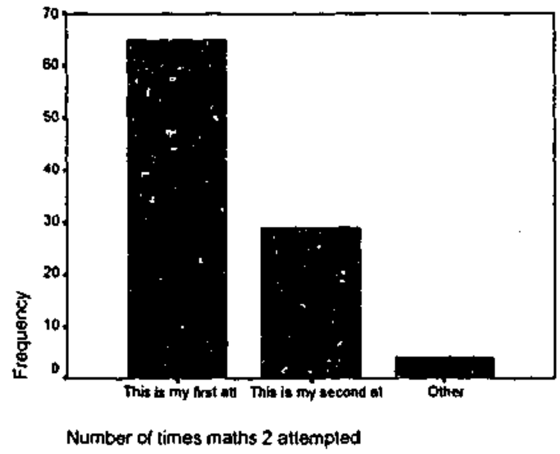



Attended Tertiary Education

How many times have you attempted doing mathematics 2?

| | Freq | Per | Cum. Per |
|---|---|---|---|
| First attempt | 65 | 65.7 | 66.3 |
| Second attempt | 29 | 29.3 | 95.9 |
| Other | 4 | 4.0 | 100.0 |
| Total | 98 | 99.0 | |
| Missing | 1 | 1.0 | |
| Total | 99 | 100.0 | |

Number of times maths 2 attempted




Employed


**Are you currently employed?**

| | Frequency | Percent |
|---|---|---|
| Yes | 29 | 29.3 |
| No | 68 | 68.7 |
| Total | 97 | 98.0 |
| Missing | 2 | 2.0 |
| Total | 99 | 100.0 |

**Occupation**

| | Frequency | Percent |
|---|---|---|
| Apprentice | 2 | 2.0 |
| Bank Officer | 1 | 1.0 |
| Bartender | 1 | 1.0 |
| Nursing Sister | 5 | 5.1 |
| Office Worker | 3 | 3.0 |
| Plant Operator | 1 | 1.0 |
| Police Officer | 3 | 3.0 |
| Radio Inspector | 1 | 1.0 |
| Research Officer | 1 | 1.0 |
| Security Guard | 1 | 1.0 |
| Soldier | 4 | 4.0 |
| Just Student | 68 | 68.7 |
| Teacher | 6 | 6.1 |
| Teacher Aid | 1 | 1.0 |
| Technician | 1 | 1.0 |
| Total | 99 | 100.0 |

# Mathematics Attitudes Survey

## Main Study

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Q1 | + | Doing mathematics is a challenge that I enjoy. | O SA | O A | O D | O SD | O NS |
| Q2 | + | Mathematics is so useful that it should be a required part of my professional skills. | O SA | O A | O D | O SD | O NS |
| Q3 | - | I don't like mathematics because it is not relevant to my traditional culture. | O SA | O A | O D | O SD | O NS |
| Q4 | - | I think Pre-University mathematics as it is taught at present is too foreign and not applicable to PNG students. | O SA | O A | O D | O SD | O NS |
| Q5 | - | I think Pre-University mathematics is too divorced from PNG traditions and culture. | O SA | O A | O D | O SD | O NS |
| Q6 | + | I get a great deal of satisfaction out of solving a mathematics problem. | O SA | O A | O D | O SD | O NS |
| Q7 | - | I don't think there is any use for mathematics in the PNG traditional culture. | O SA | O A | O D | O SD | O NS |
| Q8 | - | It takes me a long time to understand a mathematical concept. | O SA | O A | O D | O SD | O NS |
| Q9 | + | Mathematics will be useful to me in my profession. | O SA | O A | O D | O SD | O NS |
| Q10 | + | I would like to study advanced mathematics. | O SA | O A | O D | O SD | O NS |
| Q11 | - | The thought of taking another mathematics course makes me sick | O SA | O A | O D | O SD | O NS |

# Mathematics Attitudes Survey

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Q12 | + | I find mathematics to be very logical and clear. | O SA | O A | O D | O SD | O NS |
| Q13 | + | I have always enjoyed studying mathematics. | O SA | O A | O D | O SD | O NS |
| Q14 | + | It is my opinion that mathematics is necessary to keep the world running. | O SA | O A | O D | O SD | O NS |
| Q15 | - | I don't think mathematics is important in everyday life. | O SA | O A | O D | O SD | O NS |
| Q16 | + | It is my opinion that mathematics has contributed greatly to science and other fields of knowledge. | O SA | O A | O D | O SD | O NS |
| Q17 | + | I am interested and willing to acquire further knowledge of mathematics. | O SA | O A | O D | O SD | O NS |
| Q18 | + | It is my opinion that mathematics helps to develop a person's mind and teaches him or her to think. | O SA | O A | O D | O SD | O NS |
| Q19 | + | I am able to figure out most of the equations I need to solve a mathematics problem. | O SA | O A | O D | O SD | O NS |
| Q20 | - | The pace of a mathematics course is so fast that it is impossible for me to learn the subject matter thoroughly. | O SA | O A | O D | O SD | O NS |
| Q21 | + | Mathematics ideas exist in my home culture. | O SA | O A | O D | O SD | O NS |

# Mathematics Attitudes Survey

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Q22 | + | Methods of solving mathematics problems are useful in my home culture. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q23 | + | Mathematics for me is about useful and practical ideas. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q24 | + | Mathematics is very interesting and I have usually enjoyed courses in this subject. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q25 | - | There are no useful mathematical ideas in the traditional cultural activities of my people. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q26 | + | I enjoy going beyond the stated course and trying to solve new problems in mathematics. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q27 | + | I would like to develop my mathematics skills and study this subject more. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q28 | + | It is my opinion that an understanding of mathematics is needed by artists and writers as well as scientists. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q29 | - | I think that mathematics is less important to people than art or literature. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q30 | - | I consider mathematics to be dull and boring because it leaves no room for personal opinion. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q31 | - | I have never liked mathematics and it is my most dreaded subject. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |

# Mathematics Attitudes Survey

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Q32 | - | Mathematics makes me feel uneasy and confused. | O SA | O A | O D | O SD | O NS |
| Q33 | + | Mathematics for me is a worthwhile and necessary subject. | O SA | O A | O D | O SD | O NS |
| Q34 | - | Mathematics makes me feel uncomfortable and nervous. | O SA | O A | O D | O SD | O NS |
| Q35 | - | I do not need mathematics to survive in my village. | O SA | O A | O D | O SD | O NS |
| Q36 | + | I think that mathematics is useful in traditional societies. | O SA | O A | O D | O SD | O NS |
| Q37 | - | I would avoid mathematics completely if that was possible and I could still continue my studies. | O SA | O A | O D | O SD | O NS |
| Q38 | - | Mathematics is unnecessary in my chosen profession. | O SA | O A | O D | O SD | O NS |
| Q39 | - | There are so many mathematical concepts to learn that I get confused. | O SA | O A | O D | O SD | O NS |
| Q40 | + | Given the opportunity, I would take another mathematics course even though it were not required. | O SA | O A | O D | O SD | O NS |

Appendix M2b: General Statistics for the 40 Items of the MAQ - Main Study

| Item | N | Mean | Median | Std. Dev. | Skewness | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| q1 | 98 | 4.41 | 4.50 | .73 | -1.785 | .244 | 5.302 | .483 |
| q2 | 91 | 4.62 | 5.00 | .57 | -1.555 | .253 | 3.424 | .500 |
| q3 | 99 | 4.53 | 5.00 | .69 | -1.518 | .243 | 2.348 | .481 |
| q4 | 98 | 4.06 | 4.00 | .95 | -.933 | .244 | .408 | .483 |
| q5 | 99 | 3.82 | 4.00 | .94 | -.301 | .243 | -.834 | .481 |
| q6 | 99 | 4.52 | 5.00 | .56 | -.594 | .243 | -.694 | .481 |
| q7 | 98 | 4.24 | 4.00 | .91 | -1.266 | .244 | 1.362 | .483 |
| q8 | 98 | 2.83 | 2.00 | 1.25 | .239 | .244 | -1.263 | .483 |
| q9 | 99 | 4.67 | 5.00 | .65 | -2.648 | .243 | 9.703 | .481 |
| q10 | 99 | 4.34 | 5.00 | .87 | -1.681 | .243 | 3.440 | .481 |
| q11 | 98 | 4.12 | 4.00 | .93 | -1.491 | .244 | 2.664 | .483 |
| q12 | 99 | 3.60 | 4.00 | 1.03 | -.779 | .243 | -.159 | .481 |
| q13 | 97 | 4.06 | 4.00 | .94 | -1.110 | .245 | .552 | .485 |
| q14 | 99 | 4.39 | 5.00 | .73 | -1.091 | .243 | .958 | .481 |
| q15 | 99 | 4.49 | 5.00 | .84 | -2.004 | .243 | 4.178 | .481 |
| q16 | 99 | 4.80 | 5.00 | .59 | -4.217 | .243 | 21.729 | .481 |
| q17 | 99 | 4.54 | 5.00 | .66 | -1.331 | .243 | 1.496 | .481 |
| q18 | 99 | 4.70 | 5.00 | .48 | -1.144 | .243 | -.019 | .481 |
| q19 | 99 | 3.74 | 4.00 | .92 | -.968 | .243 | .743 | .481 |
| q20 | 99 | 2.82 | 3.00 | 1.25 | .096 | .243 | -1.189 | .481 |
| q21 | 99 | 3.62 | 4.00 | .91 | -.642 | .243 | .651 | .481 |
| q22 | 99 | 3.52 | 4.00 | .86 | -.536 | .243 | .374 | .481 |
| q23 | 97 | 4.41 | 4.00 | .49 | .362 | .245 | -1.909 | .485 |
| q24 | 99 | 4.15 | 4.00 | .91 | -1.477 | .243 | 2.535 | .481 |
| q25 | 99 | 3.51 | 4.00 | .99 | -.715 | .243 | .329 | .481 |
| q26 | 99 | 4.03 | 4.00 | .87 | -1.088 | .243 | 1.344 | .481 |
| q27 | 99 | 4.54 | 5.00 | .70 | -2.094 | .243 | 6.589 | .481 |
| q28 | 99 | 4.43 | 5.00 | .85 | -1.897 | .243 | 4.370 | .481 |
| q29 | 99 | 4.17 | 4.00 | .94 | -1.263 | .243 | 1.606 | .481 |
| q30 | 99 | 4.20 | 4.00 | .93 | -1.362 | .243 | 1.977 | .481 |
| q31 | 99 | 4.27 | 5.00 | 1.13 | -1.677 | .243 | 1.945 | .481 |
| q32 | 99 | 3.52 | 4.00 | 1.25 | -.549 | .243 | -.967 | .481 |
| q33 | 96 | 4.32 | 4.00 | .80 | -1.407 | .246 | 2.092 | .488 |
| q34 | 98 | 3.74 | 4.00 | 1.20 | -.784 | .244 | -.536 | .483 |
| q35 | 99 | 3.93 | 4.00 | 1.14 | -.796 | .243 | -.467 | .481 |
| q36 | 99 | 3.69 | 4.00 | .94 | -.668 | .243 | .203 | .481 |
| q37 | 98 | 4.05 | 4.00 | 1.16 | -1.352 | .244 | 1.046 | .483 |
| q38 | 99 | 4.43 | 5.00 | .80 | -1.567 | .243 | 2.258 | .481 |
| q39 | 99 | 2.68 | 2.00 | 1.19 | .431 | .243 | -1.084 | .481 |
| q40 | 99 | 3.86 | 4.00 | 1.06 | -1.025 | .243 | .388 | .481 |

Appendix M3a: **Pre-Computer Experience Questionnaire (CSQ1) - Main Study**

# Computer Attitudes Survey Questionnaire 1

## Main Study

## SECTION A

| | | | | | |
|---|---|---|---|---|---|
| Q2 | State very briefly in a sentence why you decided to join the CAI class instead of TM. | ____________ ____________ ____________ ____________ ____________ | | | |
| Q3 | I have used a computer before. | O Yes | | O No | |
| Q4 | I have used computers before in connection with; | O Computer Applications (e.g. word processing, spreadsheets etc.)<br>O Computer Games<br>O Computer Course<br>O Other (specify):__________<br>O This is my first experience with computers | | | |
| Q5 | I find handling or operating a mouse; | O V Difficult | O Difficult | O Easy | O Very Easy |
| Q6 | I find handling or operating a computer keyboard; | O V Difficult | O Difficult | O Easy | O Very Easy |
| Q7 | I find reading a line of text on the computer screen; | O V Difficult | O Difficult | O Easy | O Very Easy |

## SECTION B

| | | | | | | |
|---|---|---|---|---|---|---|
| Q9 | Computers can help me improve my understanding of mathematics. | O SA | O A | O D | O SD | O NS |
| Q10 | I consider computers to be valuable tools for learning. | O SA | O A | O D | O SD | O NS |
| Q11 | I think the world would be better off if computers have never been invented. | O SA | O A | O D | O SD | O NS |
| Q12 | I think learning mathematics using CAI would be quicker and easier for me. | O SA | O A | O D | O SD | O NS |
| Q13 | I think learning mathematics through CAI lacks the sense of presence that a human tutor provides. | O SA | O A | O D | O SD | O NS |
| Q14 | I would rather attend face-to-face tutorials with a human tutor than go through CAI. | O SA | O A | O D | O SD | O NS |
| Q15 | I would like to see more IDCE courses taught through CAI. | O SA | O A | O D | O SD | O NS |
| Q16 | I think learning mathematics through CAI would be much better than learning it from course booklets. | O SA | O A | O D | O SD | O NS |
| Q17 | I am joining CAI classes because it is a chance to use and handle computers and not necessarily to learn mathematics. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 1

| | | | | | | |
|---|---|---|---|---|---|---|
| Q18 | CAI can be a very useful way of learning mathematics if it is properly implemented. | O SA | O A | O D | O SD | O NS |
| Q19 | It is my opinion that CAI is less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorials. | O SA | O A | O D | O SD | O NS |
| Q20 | I don't think CAI can work in PNG because Papua New Guineans lack computer skills. | O SA | O A | O D | O SD | O NS |
| Q21 | I think CAI or anything to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | O SA | O A | O D | O SD | O NS |
| Q22 | I think CAI would be better in mediating mathematics learning than other more traditional mediums such as course booklets and face-to-face tutorials. | O SA | O A | O D | O SD | O NS |
| Q23 | CAI allows me to go through my maths lessons the way I like and at my own pace better. | O SA | O A | O D | O SD | O NS |
| Q24 | I think learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | O SA | O A | O D | O SD | O NS |
| Q25 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through CAI. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 1

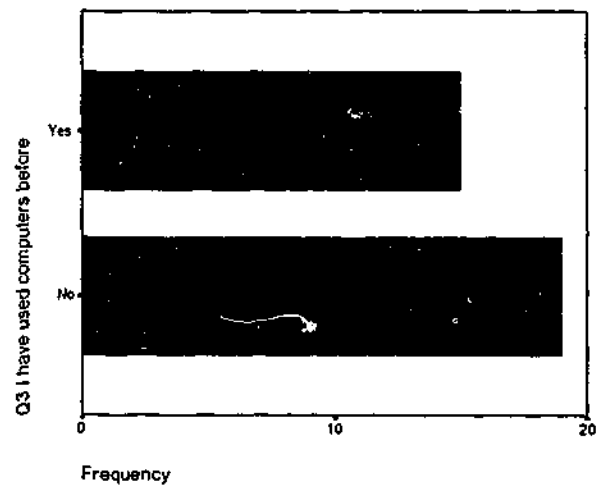
| | | | | | | |
|---|---|---|---|---|---|---|
| Q26 | I can learn mathematics better from a book in front of me than from a computer screen. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q27 | Working at my own pace using CAI is not as effective in learning mathematics as attendance at face-to-face tutorials. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q28 | I don't think CAI is as effective in mediating learning in mathematics 2 as course booklets. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q29 | I don't think CAI is as effective in mediating learning in mathematics 2 as face-to-face tutorials. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q30 | Even if I had a computer I would still prefer books and face to face tutorials to study any mathematics course including mathematics 2. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q31 | I am joining CAI because I prefer to work through my maths lessons at my own pace rather than that of a tutorial group. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |

## Appendix M3b: Response Frequency Summaries for Section A of CSQ1 - Main Study

## Section A: Tables and Charts for Items 3, 5, 6 & 7

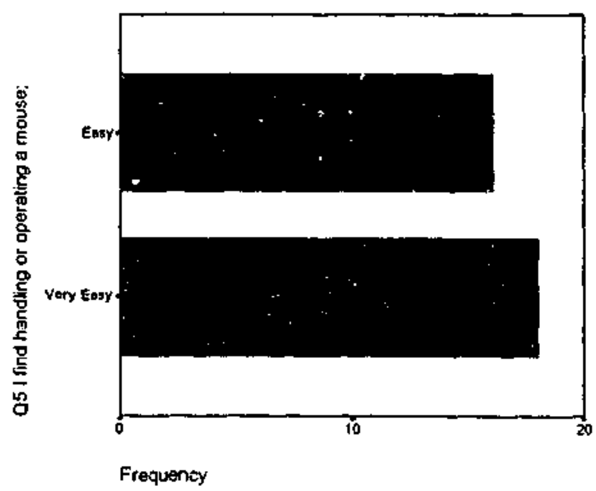
Q3 I have used computers before

| | Freq. | Percent |
|---|---|---|
| Yes | 15 | 44.1 |
| No | 19 | 55.9 |
| Total | 34 | 100.0 |



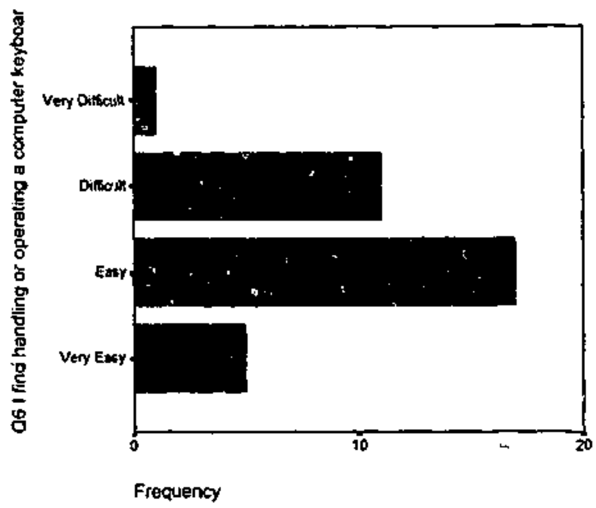

Q5 I find handling or operating a mouse;

| | Freq. | Percent |
|---|---|---|
| Easy | 16 | 47.1 |
| Very Easy | 18 | 52.9 |
| Total | 34 | 100.0 |



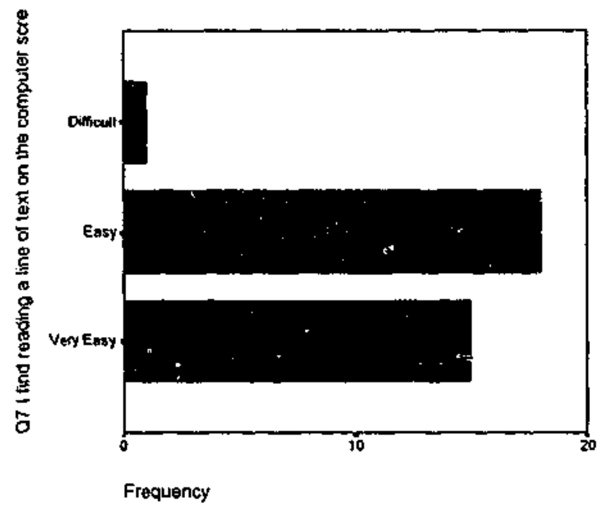
Q6 I find handling or operating a computer keyboard;

| | Freq. | Percent |
|---|---|---|
| Very Difficult | 1 | 2.9 |
| Difficult | 11 | 32.4 |
| Easy | 17 | 50.0 |
| Very Easy | 5 | 14.7 |
| Total | 34 | 100.0 |




Q7 I find reading a line of text on the computer screen;

| | Freq. | Percent |
|---|---|---|
| Difficult | 1 | 2.9 |
| Easy | 18 | 52.9 |
| Very Easy | 15 | 44.1 |
| Total | 34 | 100.0 |



Appendix M3c: General Statistics for the 23 Items of CSQ1 - Main Study

| Item | N | Mean | Median | Std. Dev. | Skewness | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Q9 | 35 | 4.31 | 4.00 | .63 | -.354 | .398 | -.581 | .778 |
| Q10 | 35 | 4.66 | 5.00 | .48 | -.692 | .398 | -1.617 | .778 |
| Q11 | 34 | 4.44 | 5.00 | .82 | -1.703 | .403 | 2.847 | .788 |
| Q12 | 35 | 4.14 | 4.00 | .88 | -.843 | .398 | .137 | .778 |
| Q13 | 35 | 2.97 | 3.00 | 1.29 | -.030 | .398 | -1.228 | .778 |
| Q14 | 35 | 3.60 | 4.00 | 1.17 | -.549 | .398 | -.841 | .778 |
| Q15 | 35 | 4.34 | 5.00 | .87 | -1.035 | .398 | -.046 | .778 |
| Q16 | 35 | 3.63 | 4.00 | 1.06 | -.280 | .398 | -1.088 | .778 |
| Q17 | 35 | 3.97 | 4.00 | 1.04 | -1.591 | .398 | 2.599 | .778 |
| Q18 | 35 | 4.60 | 5.00 | .55 | -.974 | .398 | -.031 | .778 |
| Q19 | 34 | 3.59 | 4.00 | 1.10 | -.668 | .403 | .084 | .788 |
| Q20 | 35 | 3.83 | 4.00 | 1.20 | -.950 | .398 | .052 | .778 |
| Q21 | 34 | 4.38 | 5.00 | .82 | -1.191 | .403 | .769 | .788 |
| Q22 | 35 | 3.77 | 4.00 | .94 | -.406 | .398 | -.588 | .778 |
| Q23 | 35 | 4.31 | 4.00 | .76 | -1.039 | .398 | 1.105 | .778 |
| Q24 | 35 | 4.31 | 4.00 | .76 | -.609 | .398 | -.971 | .778 |
| Q25 | 35 | 4.60 | 5.00 | .60 | -1.258 | .398 | .671 | .778 |
| Q26 | 35 | 3.37 | 4.00 | 1.06 | -.349 | .398 | -.763 | .778 |
| Q27 | 35 | 3.69 | 4.00 | 1.05 | -.444 | .398 | -.934 | .778 |
| Q28 | 35 | 3.80 | 4.00 | 1.05 | -.541 | .398 | -.822 | .778 |
| Q29 | 35 | 3.63 | 4.00 | .94 | -.507 | .398 | -.558 | .778 |
| Q30 | 35 | 3.49 | 4.00 | 1.22 | -.632 | .398 | -.495 | .778 |
| Q31 | 35 | 4.03 | 4.00 | 1.01 | -.957 | .398 | -.017 | .778 |

## Appendix M3d: Reliability Analysis for the CSQ1 Overall Likert Scale-Main Study

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Alpha if Item Deleted |
|---|---|---|---|---|
| CSQ19 | 87.6250 | 106.6290 | .5842 | .8461 |
| CSQ110 | 87.3125 | 109.7702 | .4877 | .8501 |
| CSQ111 | 87.5625 | 108.5766 | .3243 | .8524 |
| CSQ112 | 87.7500 | 105.1613 | .5627 | .8453 |
| CSQ113 | 88.8750 | 105.5968 | .2930 | .8562 |
| CSQ114 | 88.3750 | 105.2097 | .3312 | .8539 |
| CSQ115 | 87.6250 | 102.9516 | .6102 | .8429 |
| CSQ116 | 88.2813 | 103.5635 | .4746 | .8473 |
| CSQ117 | 87.9375 | 113.4798 | .0294 | .8624 |
| CSQ118 | 87.3438 | 110.0393 | .3951 | .8513 |
| CSQ119 | 88.3750 | 107.8548 | .2466 | .8567 |
| CSQ120 | 88.1250 | 114.8226 | -.0527 | .8702 |
| CSQ121 | 87.5313 | 107.6119 | .4022 | .8501 |
| CSQ122 | 88.2188 | 105.7893 | .4216 | .8493 |
| CSQ123 | 87.6250 | 105.3387 | .5909 | .8450 |
| CSQ124 | 87.6563 | 103.5232 | .7238 | .8413 |
| CSQ125 | 87.3750 | 106.5645 | .6296 | .8456 |
| CSQ126 | 88.6250 | 105.9194 | .3591 | .8518 |
| CSQ127 | 88.2813 | 99.1119 | .6738 | .8389 |
| CSQ128 | 88.1563 | 98.7813 | .6902 | .8382 |
| CSQ129 | 88.3438 | 103.7167 | .5167 | .8458 |
| CSQ130 | 88.5000 | 101.8710 | .4468 | .8489 |
| CSQ131 | 87.8125 | 102.6734 | .6125 | .8427 |

Reliability Coefficients

N of Cases = 32.0 N of Items = 23

Alpha = .8551

**Appendix M4a: Post-Computer Experience Questionnaire (CSQ2)-Main Study**

# Computer Attitudes Survey Questionnaire 2

## Main Study

## SECTION A

| | | | | |
|---|---|---|---|---|
| Q2 | I find handling or operating a mouse; | ○ Very difficult | ○ Difficult | ○ No problems at all |
| Q3 | I find handling or operating a computer keyboard; | ○ Very difficult | ○ Difficult | ○ No problems at all |
| Q4 | I find reading a line of text on the computer screen; | ○ Very difficult | ○ Difficult | ○ No problems at all |

| | | | |
|---|---|---|---|
| Q5 | Were the CAI lessons easy to use? | ○ Definitely not<br>○ Not really | ○ Yes<br>○ Yes, definitely |
| Q6 | Were you happy with the amount of control you had over the CAI lessons? | ○ Definitely not<br>○ Not really | ○ Yes<br>○ Yes, definitely |
| Q7 | Do you think you learn faster and better on computer? | ○ Definitely not<br>○ Not really | ○ Yes<br>○ Yes, definitely |

## SECTION B

| | | | | | | |
|---|---|---|---|---|---|---|
| Q9 | It is easier for me to read a line of text on a page in a book than on the screen. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q10 | Computers have helped me improve my understanding of mathematics. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q11 | The CAI-based mathematics 2 course has helped me improve my understanding of the contents of the course. | O SA | O A | O D | O SD | O NS |
| Q12 | I consider computers to be valuable tools for learning. | O SA | O A | O D | O SD | O NS |
| Q13 | Learning mathematics using CAI is quicker and easier for me. | O SA | O A | O D | O SD | O NS |
| Q14 | I would take another mathematics course through CAI having had this experience. | O SA | O A | O D | O SD | O NS |
| Q15 | Learning mathematics through CAI for me lacks the sense of presence that a human tutor provides. | O SA | O A | O D | O SD | O NS |
| Q16 | I would rather attend face-to-face tutorials with a human tutor than go through CAI again. | O SA | O A | O D | O SD | O NS |
| Q17 | I would like to see more IDCE courses taught through CAI. | O SA | O A | O D | O SD | O NS |
| Q18 | Learning mathematics through CAI for me is much better than learning it from course booklets. | O SA | O A | O D | O SD | O NS |
| Q19 | I believe the time has come for computer applications like CAI in Papua New Guinea. | O SA | O A | O D | O SD | O NS |
| Q20 | It is my opinion that CAI as a mode of learning in distance education in PNG should be pursued more vigorously. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q21 | I find CAI to be less effective in mediating learning in mathematics 2 than the usual 2 hours per week face-to-face tutorial. | O SA | O A | O D | O SD | O NS |
| Q22 | I don't think CAI can work in PNG because Papua New Guineans lack computer skills. | O SA | O A | O D | O SD | O NS |
| Q23 | I think CAI or any thing to do with computers are alien to the PNG culture and we should not adopt such alien ideas. | O SA | O A | O D | O SD | O NS |
| Q24 | CAI is better in mediating mathematics learning for me than other more traditional mediums such as course booklets and face-to-face tutorials. | O SA | O A | O D | O SD | O NS |
| Q25 | I think learning mathematics through CAI should become part of all mathematics courses offered through the distance mode. | O SA | O A | O D | O SD | O NS |
| Q26 | I would like to learn how to use the computer more effectively. | O SA | O A | O D | O SD | O NS |
| Q27 | It is my opinion that computers can really make one's life more difficult. | O SA | O A | O D | O SD | O NS |
| Q28 | CAI and computers are not available back in the village so why should I waste my time learning mathematics through CAI. | O SA | O A | O D | O SD | O NS |
| Q29 | I can learn mathematics better from a book in front of me than from a computer screen. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 2

| | | | | | | |
|---|---|---|---|---|---|---|
| Q30 | The color, graphics and animation in CAI has made the learning of concepts in mathematics 2 interesting and easy for me. | O SA | O A | O D | O SD | O NS |
| Q31 | I think CAI is more effective in mediating learning in mathematics 2 than course booklets. | O SA | O A | O D | O SD | O NS |
| Q32 | Computers are here to stay so I might as well learn to use them effectively for learning purposes. | O SA | O A | O D | O SD | O NS |
| Q33 | I would like to learn how to use the computer more effectively | O SA | O A | O D | O SD | O NS |
| Q34 | I consider CAI to be less effective in mediating learning in mathematics 2 than course booklets. | O SA | O A | O D | O SD | O NS |
| Q35 | Being able to work at my own pace in covering the units in mathematics 2 is one aspect of CAI I find useful. | O SA | O A | O D | O SD | O NS |
| Q36 | The navigation capabilities provided in the CAI software has made my mathematics learning enjoyable and effective. | O SA | O A | O D | O SD | O NS |
| Q37 | Mathematics comes alive for me when taught through CAI. | O SA | O A | O D | O SD | O NS |
| Q38 | Concepts in mathematics that I found difficult before are clearer when presented through CAI. | O SA | O A | O D | O SD | O NS |

# Computer Attitudes Survey Questionnaire 2

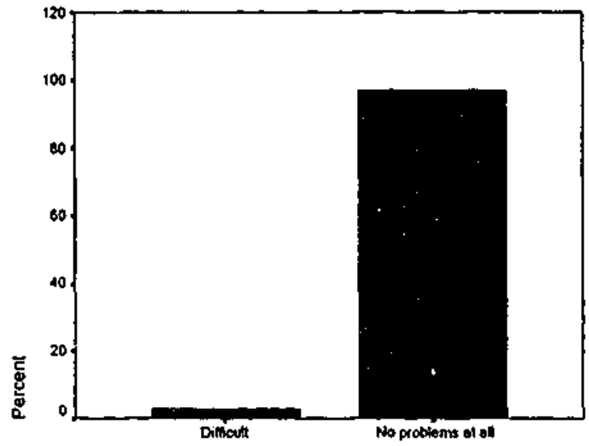
| | | | | | | |
|---|---|---|---|---|---|---|
| Q39 | The navigation capabilities provided in the CAI software is clear and logical so that I know exactly where I am in the CAI mediated mathematics lessons. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q40 | The color, graphics and animation in CAI is distracting for me making CAI less effective as a learning tool. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q41 | The ability of CAI to provide immediate feedback is no different to looking up the answers to exercises provided in the back of a unit booklet. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q42 | The navigation capabilities provided in the CAI software makes no difference for me in learning mathematical ideas. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q43 | The ability of the CAI software to provide immediate feedback in the exercises provided in some topics has increased my interest and effectiveness in mathematics 2. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q44 | Working at my own pace using CAI is not as effective in learning mathematics as attendance at face-to-face tutorials. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |
| Q45 | Even if I had a computer I would still prefer books and face-to-face tutorials to study any mathematics course including mathematics 2. | ○ SA | ○ A | ○ D | ○ SD | ○ NS |

## Appendix M4b: Response Frequency Summaries for Section A of CSQ2

## Section A: Tables and Charts for Items 2, 3, 4, 5, 6 & 7

Q2 I find handling or operating a mouse;

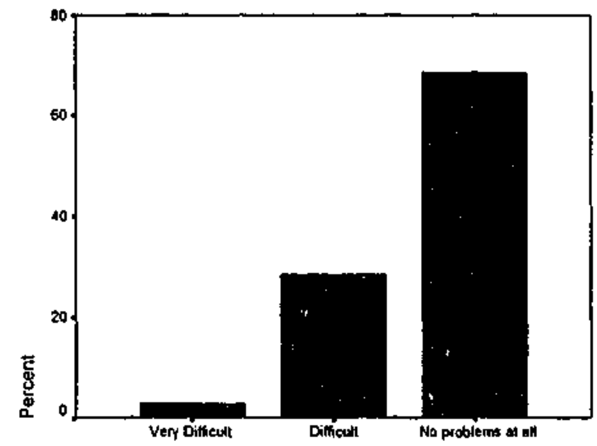
| | Freq | Percent |
|---|---|---|
| Difficult | 1 | 2.9 |
| No problems at all | 34 | 97.1 |
| Total | 35 | 100.0 |



Q2 I find handling or operating a mouse;

Q3 I find handling or operating a computer keyboard;

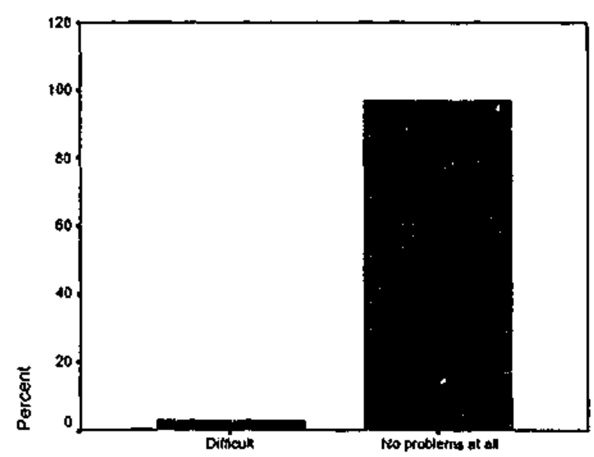
| | Freq | Percent |
|---|---|---|
| Very Difficult | 1 | 2.9 |
| Difficult | 10 | 28.6 |
| No problems at all | 24 | 68.6 |
| Total | 35 | 100.0 |



Q3 I find handling or operating a computer keyboard;

Q4 I find reading a line of text on the computer screen;

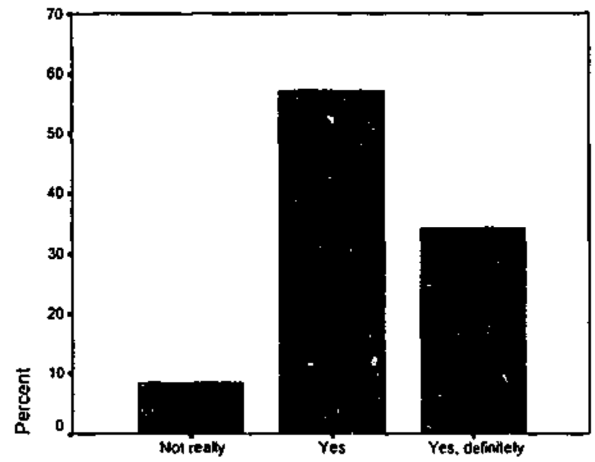
| | Freq | Percent |
|---|---|---|
| Difficult | 1 | 2.9 |
| No problems at all | 34 | 97.1 |
| Total | 35 | 100.0 |



Q4 I find reading a line of text on the computer screen;

Q5 Were the CAI lessons easy to use?

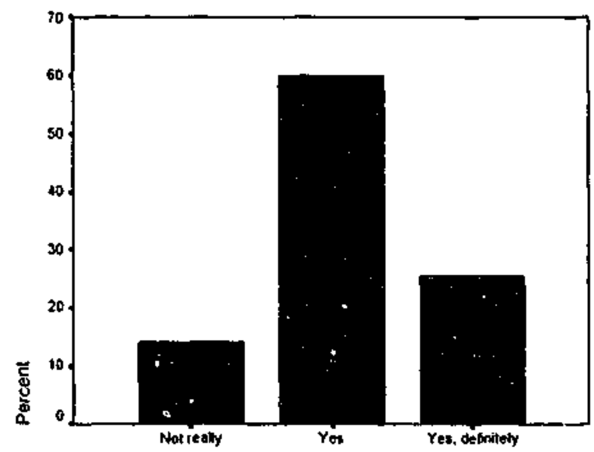
| | Freq | Percent |
|---|---|---|
| Not really | 3 | 8.6 |
| Yes | 20 | 57.1 |
| Yes, definitely | 12 | 34.3 |
| Total | 35 | 100.0 |




Q5 Were the CAI lessons easy to use?

Q6 Were you happy with the amount of control you had over the CAI lessons?

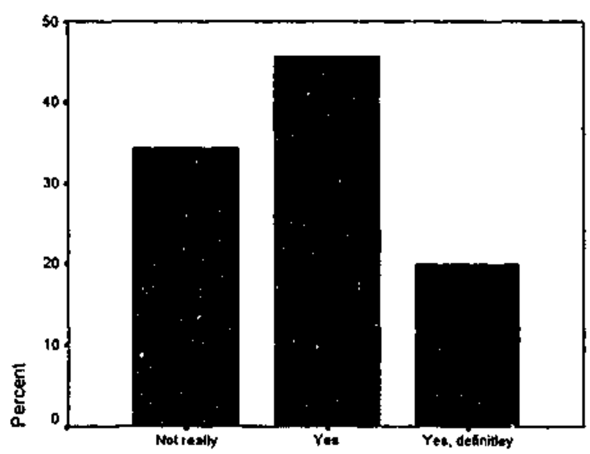
| | Freq | Percent |
|---|---|---|
| Not really | 5 | 14.3 |
| Yes | 21 | 60.0 |
| Yes, definitely | 9 | 25.7 |
| Total | 35 | 100.0 |




Q6 Were you happy with the amount of control you had over the CAI lesson

Q7 Do you think you learn faster and better on computer?

| | Freq | Percent |
|---|---|---|
| Not really | 12 | 34.3 |
| Yes | 16 | 45.7 |
| Yes, definitley | 7 | 20.0 |
| Total | 35 | 100.0 |




Q7 Do you think you learn faster and better on computer?

Appendix M4c: General Statistics for the 37 Items of CSQ2 - Main Study

| Item | N | Mean | Median | Std. Dev. | Skewness | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Qn9 | 35 | 3.60 | 4.00 | 1.01 | -.566 | .398 | -.798 | .778 |
| Qn10 | 35 | 3.91 | 4.00 | .78 | -1.024 | .398 | 1.498 | .778 |
| Qn11 | 35 | 4.23 | 4.00 | .65 | -.943 | .398 | 2.958 | .778 |
| Qn12 | 35 | 4.80 | 5.00 | .41 | -1.568 | .398 | .483 | .778 |
| Qn13 | 35 | 3.94 | 4.00 | .91 | -.891 | .398 | .399 | .778 |
| Qn14 | 35 | 4.51 | 5.00 | .70 | -1.678 | .398 | 3.551 | .778 |
| Qn15 | 35 | 3.03 | 3.00 | 1.25 | .232 | .398 | -1.331 | .778 |
| Qn16 | 35 | 3.51 | 4.00 | 1.07 | -.886 | .398 | .151 | .778 |
| Qn17 | 35 | 4.49 | 5.00 | .85 | -1.762 | .398 | 2.557 | .778 |
| Qn18 | 35 | 3.66 | 4.00 | 1.11 | -.901 | .398 | .272 | .778 |
| Qn19 | 35 | 4.54 | 5.00 | .66 | -1.156 | .398 | .258 | .778 |
| Qn20 | 35 | 4.46 | 5.00 | .61 | -.649 | .398 | -.452 | .778 |
| Qn21 | 35 | 3.63 | 4.00 | .97 | -.792 | .398 | .440 | .778 |
| Qn22 | 35 | 4.23 | 4.00 | .91 | -1.726 | .398 | 4.038 | .778 |
| Qn23 | 35 | 4.57 | 5.00 | .56 | -.837 | .398 | -.310 | .778 |
| Qn24 | 35 | 3.51 | 4.00 | 1.04 | -.373 | .398 | -1.093 | .778 |
| Qn25 | 35 | 4.40 | 5.00 | .85 | -1.515 | .398 | 1.957 | .778 |
| Qn26 | 35 | 4.83 | 5.00 | .38 | -1.823 | .398 | 1.399 | .778 |
| Qn27 | 34 | 4.29 | 5.00 | 1.03 | -2.052 | .403 | 4.619 | .788 |
| Qn28 | 35 | 4.51 | 5.00 | .82 | -2.614 | .398 | 9.248 | .778 |
| Qn29 | 35 | 3.69 | 4.00 | 1.02 | -.887 | .398 | .292 | .778 |
| Qn30 | 35 | 4.23 | 4.00 | .84 | -1.092 | .398 | .988 | .778 |
| Qn31 | 35 | 3.91 | 4.00 | .95 | -.474 | .398 | -.659 | .778 |
| Qn32 | 35 | 4.66 | 5.00 | .54 | -1.278 | .398 | .758 | .778 |
| Qn33 | 35 | 4.89 | 5.00 | .32 | -2.535 | .398 | 4.689 | .778 |
| Qn34 | 35 | 3.91 | 4.00 | .78 | -.631 | .398 | .561 | .778 |
| Qn35 | 35 | 4.34 | 4.00 | .73 | -1.129 | .398 | 1.768 | .778 |
| Qn36 | 35 | 4.26 | 4.00 | .78 | -1.285 | .398 | 2.286 | .778 |
| Qn37 | 35 | 4.11 | 4.00 | .68 | -.745 | .398 | 1.779 | .778 |
| Qn38 | 35 | 4.06 | 4.00 | .73 | -1.069 | .398 | 2.377 | .778 |
| Qn39 | 35 | 4.17 | 4.00 | .71 | -.788 | .398 | [illegible] | .778 |
| Qn40 | 35 | 4.14 | 4.00 | .73 | -2.131 | .398 | 9.351 | .778 |
| Qn41 | 35 | [illegible] | 2.00 | 1.22 | .530 | .398 | -.868 | .778 |
| Qn42 | 35 | 2.8[illegible] | 2.00 | .98 | .560 | .398 | -1.347 | .778 |
| Qn43 | 35 | 4.14 | 4.00 | .73 | -1.182 | .398 | 2.695 | .778 |
| Qn44 | 35 | 3.86 | 4.00 | .97 | -.508 | .398 | -.621 | .778 |
| Qn45 | 35 | 3.74 | 4.00 | 1.07 | -.528 | .398 | -.889 | .778 |

## Appendix M4d: Reliability Analysis for the CSQ2 overall Likert scale-main study

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Alpha if Item Deleted |
|---|---|---|---|---|
| CSQ29 | 146.5882 | 202.5526 | .5340 | .8971 |
| CSQ210 | 146.3235 | 207.1346 | .4674 | .8983 |
| CSQ211 | 146.0294 | 204.0900 | .7604 | .8953 |
| CSQ212 | 145.4412 | 210.0116 | .6933 | .8979 |
| CSQ213 | 146.2941 | 201.0018 | .6362 | .8955 |
| CSQ214 | 145.7353 | 203.5945 | .7103 | .8954 |
| CSQ215 | 147.1765 | 211.3012 | .1524 | .9055 |
| CSQ216 | 146.6765 | 208.8922 | .2779 | .9018 |
| CSQ217 | 145.7647 | 198.4278 | .7938 | .8932 |
| CSQ218 | 146.5882 | 207.3405 | .3032 | .9016 |
| CSQ219 | 145.7059 | 204.3351 | .7212 | .8956 |
| CSQ220 | 145.7941 | 205.5018 | .7146 | .8960 |
| CSQ221 | 146.6176 | 211.1524 | .2202 | .9025 |
| CSQ222 | 146.0000 | 202.6667 | .5673 | .8966 |
| CSQ223 | 145.6765 | 217.0740 | .0629 | .9028 |
| CSQ224 | 146.7353 | 202.6248 | .4909 | .8979 |
| CSQ225 | 145.8235 | 201.3012 | .6741 | .8951 |
| CSQ226 | 145.4118 | 211.5829 | .5947 | .8987 |
| CSQ227 | 145.9412 | 217.3904 | -.0008 | .9065 |
| CSQ228 | 145.6765 | 211.4982 | .2761 | .9010 |
| CSQ229 | 146.5000 | 210.0758 | .2555 | .9019 |
| CSQ230 | 146.0000 | 198.6061 | .7923 | .8933 |
| CSQ231 | 146.3235 | 199.8012 | .6486 | .8951 |
| CSQ232 | 145.5882 | 214.1283 | .2515 | .9010 |
| CSQ233 | 145.3529 | 214.2959 | .4204 | .9002 |
| CSQ234 | 146.3235 | 210.4073 | .3214 | .9004 |
| CSQ235 | 145.9118 | 207.1132 | .5155 | .8978 |
| CSQ236 | 145.9706 | 200.8779 | .7554 | .8943 |
| CSQ237 | 146.1176 | 204.4100 | .6906 | .8958 |
| CSQ238 | 146.1765 | 206.8770 | .5199 | .8977 |
| CSQ239 | 146.0882 | 203.2950 | .7313 | .8952 |
| CSQ240 | 146.0882 | 213.9617 | .1798 | .9021 |
| CSQ241 | 147.6765 | 224.4073 | -.2052 | .9122 |
| CSQ242 | 147.3824 | 217.6373 | -.0064 | .9063 |
| CSQ243 | 146.0882 | 201.7799 | .7615 | .8945 |
| CSQ244 | 146.3824 | 201.5766 | .5653 | .8965 |
| CSQ245 | 146.5000 | 203.1061 | .4590 | .8985 |

Reliability Coefficients

N of Cases = 34.0 N of Items = 37

Alpha = .9014

# Tables from the Factor Analysis of the MAQ Data - Main Study

Appendix M5a: Communalities

| | Initial | Extraction |
|---|---|---|
| Q1 | 1.000 | .751 |
| Q2 | 1.000 | .740 |
| Q3 | 1.000 | .770 |
| Q4 | 1.000 | .668 |
| Q5 | 1.000 | .742 |
| Q6 | 1.000 | .652 |
| Q7 | 1.000 | .748 |
| Q8 | 1.000 | .721 |
| Q9 | 1.000 | .842 |
| Q10 | 1.000 | .732 |
| Q11 | 1.000 | .622 |
| Q12 | 1.000 | .638 |
| Q13 | 1.000 | .789 |
| Q14 | 1.000 | .759 |
| Q15 | 1.000 | .640 |
| Q16 | 1.000 | .664 |
| Q17 | 1.000 | .811 |
| Q18 | 1.000 | .603 |
| Q19 | 1.000 | .765 |
| Q20 | 1.000 | .691 |
| Q21 | 1.000 | .786 |
| Q22 | 1.000 | .763 |
| Q23 | 1.000 | .739 |
| Q24 | 1.000 | .738 |
| Q25 | 1.000 | .571 |
| Q26 | 1.000 | .712 |
| Q27 | 1.000 | .650 |
| Q28 | 1.000 | .711 |
| Q29 | 1.000 | .787 |
| Q30 | 1.000 | .699 |
| Q31 | 1.000 | .701 |
| Q32 | 1.000 | .786 |
| Q33 | 1.000 | .793 |
| Q34 | 1.000 | .741 |
| Q35 | 1.000 | .658 |
| Q36 | 1.000 | .721 |
| Q37 | 1.000 | .729 |
| Q38 | 1.000 | .719 |
| Q39 | 1.000 | .696 |
| Q40 | 1.000 | .677 |

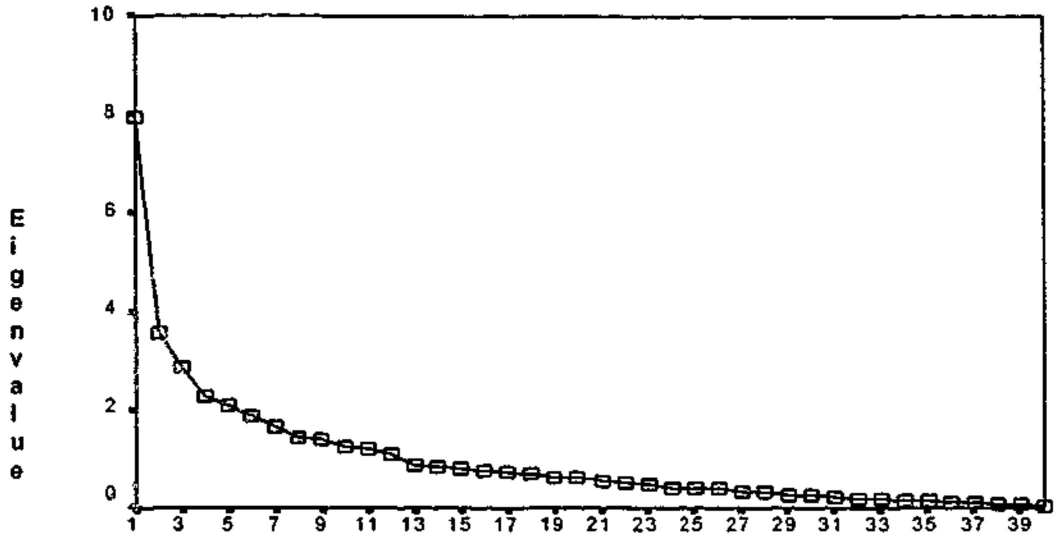
Extraction Method: Principal Component Analysis.

**Appendix M5b: Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Var | Cumul % | Total | % of Var | Cumul % |
| 1 | 7.946 | 19.865 | 19.865 | 7.946 | 19.865 | 19.865 |
| 2 | 3.575 | 8.937 | 28.802 | 3.575 | 8.937 | 28.802 |
| 3 | 2.884 | 7.210 | 36.012 | 2.884 | 7.210 | 36.012 |
| 4 | 2.279 | 5.699 | 41.710 | 2.279 | 5.699 | 41.710 |
| 5 | 2.088 | 5.219 | 46.930 | 2.088 | 5.219 | 46.930 |
| 6 | 1.893 | 4.732 | 7.946 | 19.865 | 19.865 | 7.946 |
| 7 | 1.649 | 4.123 | 3.575 | 8.937 | 28.802 | 3.575 |
| 8 | 1.442 | 3.605 | 2.884 | 7.210 | 36.012 | 2.884 |
| 9 | 1.395 | 3.487 | 2.279 | 5.699 | 41.710 | 2.279 |
| 10 | 1.265 | 3.163 | 2.088 | 5.219 | 46.930 | 2.088 |
| 11 | 1.219 | 3.046 | 1.893 | 4.732 | 51.661 | 1.893 |
| 12 | 1.088 | 2.721 | 1.649 | 4.123 | 55.784 | 1.649 |
| 13 | .872 | 2.180 | 1.442 | 3.605 | 59.389 | 1.442 |
| 14 | .839 | 2.098 | 1.395 | 3.487 | 62.876 | 1.395 |
| 15 | .818 | 2.045 | 1.265 | 3.163 | 66.040 | 1.265 |
| 16 | .759 | 1.898 | 1.219 | 3.046 | 69.086 | 1.219 |
| 17 | .727 | 1.818 | 1.088 | 2.721 | 71.807 | 1.088 |
| 18 | .715 | 1.788 | .872 | 2.180 | 73.987 | |
| 19 | .623 | 1.557 | .839 | 2.098 | 76.086 | |
| 20 | .617 | 1.541 | .818 | 2.045 | 78.131 | |
| 21 | .554 | 1.386 | .759 | 1.898 | 80.029 | |
| 22 | .529 | 1.324 | .727 | 1.818 | 81.846 | |
| 23 | .489 | 1.222 | .715 | 1.788 | 83.635 | |
| 24 | .409 | 1.023 | .623 | 1.557 | 85.192 | |
| 25 | .401 | 1.002 | .617 | 1.541 | 86.733 | |
| 26 | .395 | .987 | .554 | 1.386 | 88.119 | |
| 27 | .345 | .863 | .529 | 1.324 | 89.442 | |
| 28 | .329 | .823 | .489 | 1.222 | 90.664 | |
| 29 | .266 | .666 | .409 | 1.023 | 91.687 | |
| 30 | .245 | .613 | .401 | 1.002 | 92.689 | |
| 31 | .225 | .563 | .395 | .987 | 93.676 | |
| 32 | .200 | .500 | .345 | .863 | 94.540 | |
| 33 | .171 | .427 | .329 | .823 | 95.362 | |
| 34 | .160 | .401 | .266 | .666 | 96.028 | |
| 35 | .156 | .390 | .245 | .613 | 96.641 | |
| 36 | .127 | .318 | .225 | .563 | 97.204 | |
| 37 | .098 | .246 | .200 | .500 | 97.705 | |
| 38 | .084 | .210 | .171 | .427 | 98.132 | |
| 39 | .075 | .189 | .160 | .401 | 98.533 | |
| 40 | .046 | .115 | .156 | .390 | 98.923 | |

Extraction Method: Principal Component Analysis.

**Appendix M5c: Scree Plot**




Component Number

# Results of the Rotation of factors

**Appendix M6a: Total Variance Explained**

| Component | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 8.383 | 20.958 | 20.958 | 4.826 | 12.065 | 12.065 |
| 2 | 3.201 | 8.003 | 28.960 | 4.255 | 10.638 | 22.702 |
| 3 | 2.690 | 6.726 | 35.686 | 3.951 | 9.878 | 32.580 |
| 4 | 2.107 | 5.267 | 40.953 | 3.349 | 8.373 | 40.953 |

Extraction Method: Principal Component Analysis.

**Appendix M6b:** **Rotated Component Matrix**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Q36 I think that mathematics is useful in traditional societies. | .679 | | | |
| Q21 Mathematics ideas exist in my home culture. | .614 | | | |
| Q7 I don't think there is any use for mathematics in the PNG traditional culture. | .592 | | | |
| Q29 I think that mathematics is less important to people than art or literature. | .587 | | | |
| Q22 Methods of solving mathematics problems are useful in my home culture. | .545 | | | |
| Q35 I do not need mathematics to survive in my village. | .526 | | | |
| Q30 I consider mathematics to be dull and boring because it leaves no room for personal opinion. | .506 | | | |
| Q15 I don't think mathematics is important in everyday life. | .501 | | | |
| Q25 There are no useful mathematical ideas in the traditional cultural activities of my people. | .495 | | | |
| Q11 The thought of taking another mathematics course makes me sick. | | | | |
| Q37 I would avoid mathematics completely if that was possible and I could still continue my studies. | | | | |
| Q5 I think pre-university mathematics is too divorced from PNG traditions and culture. | | | | |
| Q8 It takes me a long time to understand a mathematical concept. | | | | |
| Q3 I don't like mathematics because it is not relevant to my traditional culture. | | | | |
| Q4 I think pre-university mathematics as it is taught at present is too foreign and not applicable to PNG students. | | | | |
| Q28 It is my opinion that an understanding of mathematics is needed by artists and writers as well as scientists. | | | | |
| Q34 Mathematics makes me uncomfortable and nervous. | | .720 | | |
| Q12 I find mathematics to be very logical and clear. | | .697 | | |
| Q32 Mathematics makes me feel uneasy and confused. | | .681 | | |
| Q39 There are so many mathematical concepts to learn that I get confused. | | .588 | | |
| Q19 I am able to figure out most of the equations I need to solve a mathematics problem. | | .555 | | |
| Q20 The pace of a mathematics course is so fast that it is impossible for me to learn the subject matter thoroughly. | | .537 | | |
| Q26 I enjoy going beyond the stated course and trying to solve new problems in mathematics. | | .504 | | |
| Q13 I have always enjoyed studying mathematics. | | | | |
| Q24 Mathematics is very interesting and I have usually enjoyed courses in this subject. | | | | |
| Q27 I would like to develop my mathematics skills and study this subject more. | | | .655 | |
| Q17 I am interested and willing to acquire further knowledge of mathematics. | | | .629 | |
| Q38 Mathematics is unnecessary in my chosen profession. | | | .565 | |
| Q6 I get a great deal of satisfaction out of solving a mathematics problem | | | .555 | |
| Q16 It is my opinion that mathematics has contributed greatly to science and other fields of knowledge. | | | .552 | |
| Q18 It is my opinion that mathematics helps to develop a person's mind and teaches him or her to think. | | | .515 | |
| Q40 Given the opportunity I would take another mathematics course even though it were not required. | | | | |
| Q1 Doing Mathematics is a challenge I enjoy. | | | | |
| Q14 it is my opinion that mathematics is necessay to keep the world running. | | | | |
| Q23 Mathematics for me is about useful and practical ideas. | | | | |
| Q9 Mathematics will be useful to me in my profession. | | | | .738 |
| Q2 Mathematics is so useful that it should be a required part of my professional skills. | | | | .672 |
| Q10 I would like to study advanced mathematics. | | | .499 | .575 |
| Q31 I have never liked mathematics and it is my most dreaded subject. | | | | .552 |
| Q33 Mathematics for me is a worthwhile and necessary subject. | | | | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 9 iterations.

Appendix M7: Correlation Coefficient Matrix to Show Convergent and Discriminant Validity for the Four Extracted Factors of the MAQ

Spearman Rank Correlation Coefficient Grid Contrasting Significant Values Versus non-Significant Values Graphically

| | 7 | 15 | 21 | 22 | 25 | 29 | 30 | 35 | 36 | 12 | 19 | 20 | 26 | 32 | 34 | 39 | 6 | 16 | 17 | 18 | 27 | 38 | 2 | 9 | 10 | 31 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1.00 | SS | SS | N | N | SS | SS | SS | SS | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | 7 |
| 15 | SS | 1.00 | SS | SS | N | SS | N | SS | SS | N | N | N | N | N | N | N | SS | SS | N | N | N | SS | N | SS | S | N | 15 |
| 21 | SS | SS | 1.00 | SS | SS | SS | SS | SS | SS | N | N | S | N | S | N | N | N | N | N | N | N | S | S | N | N | N | 21 |
| 22 | N | SS | SS | 1.00 | SS | SS | N | N | SS | N | SS | SS | N | S | SS | N | N | N | N | N | N | N | SS | N | N | N | 22 |
| 25 | N | N | SS | SS | 1.00 | N | N | N | SS | N | S | SS | N | S | N | N | N | N | N | N | N | N | N | N | N | N | 25 |
| 29 | SS | SS | SS | SS | N | 1.00 | SS | SS | SS | N | N | SS | N | N | N | N | SS | N | N | N | N | SS | N | N | N | N | 29 |
| 30 | SS | N | S | N | N | SS | 1.00 | S | S | N | N | S | N | N | S | S | SS | N | N | N | N | SS | N | N | N | SS | 30 |
| 35 | SS | SS | SS | N | N | SS | S | 1.00 | SS | N | N | S | N | N | N | N | S | N | SS | N | N | N | N | SS | S | N | 35 |
| 36 | SS | SS | SS | SS | SS | SS | S | SS | 1.00 | N | N | S | N | N | N | S | N | N | N | N | N | SS | N | SS | N | SS | 36 |
| 12 | N | N | N | N | N | N | N | N | N | 1.00 | SS | SS | SS | SS | SS | SS | SS | N | SS | S | N | N | S | N | SS | SS | 12 |
| 19 | N | N | N | SS | S | N | N | N | N | SS | 1.00 | S | SS | SS | SS | S | S | S | SS | S | S | N | N | N | S | N | 19 |
| 20 | N | N | S | SS | SS | SS | SS | S | S | SS | S | 1.00 | SS | SS | SS | SS | S | N | N | N | N | N | N | N | N | SS | 20 |
| 26 | N | N | N | N | N | N | N | N | N | SS | SS | SS | 1.00 | SS | SS | SS | SS | N | SS | SS | SS | SS | N | S | SS | S | 26 |
| 32 | N | N | S | S | S | N | N | N | N | SS | SS | SS | SS | 1.00 | SS | SS | N | N | SS | N | N | S | N | SS | S | SS | 32 |
| 34 | N | N | N | SS | N | N | S | N | N | SS | SS | SS | SS | SS | 1.00 | SS | N | N | S | S | N | SS | N | N | SS | SS | 34 |
| 39 | N | N | N | N | N | N | S | N | S | SS | S | SS | SS | SS | SS | 1.00 | N | N | N | N | N | S | N | N | S | SS | 39 |
| 6 | N | SS | N | N | N | SS | SS | S | N | SS | S | S | SS | N | N | N | 1.00 | S | SS | SS | SS | SS | N | S | SS | S | 6 |
| 16 | N | SS | N | N | N | N | N | N | N | N | S | N | N | N | N | N | S | 1.00 | SS | SS | SS | S | N | S | N | N | 16 |
| 17 | N | N | N | N | N | N | N | SS | N | SS | SS | N | SS | S | S | N | SS | SS | 1.00 | SS | SS | SS | SS | SS | SS | SS | 17 |
| 18 | N | N | N | N | N | N | N | N | N | SS | S | N | SS | N | SS | N | SS | SS | SS | 1.00 | SS | SS | N | S | S | N | 18 |
| 27 | N | N | N | N | N | N | N | N | N | N | SS | N | SS | N | N | N | SS | SS | SS | SS | 1.00 | SS | N | SS | SS | S | 27 |
| 38 | N | SS | S | N | N | SS | SS | N | SS | N | N | N | SS | S | SS | S | SS | S | SS | SS | SS | 1.00 | N | SS | SS | SS | 38 |
| 2 | N | N | S | S | N | N | N | N | N | S | N | N | N | N | N | N | N | N | SS | N | N | N | 1.00 | SS | S | SS | 2 |
| 9 | N | SS | N | N | N | N | N | S | SS | N | N | N | S | SS | N | N | S | S | SS | S | SS | SS | SS | 1.00 | SS | SS | 9 |
| 10 | N | S | N | N | N | N | N | S | N | SS | S | N | SS | SS | SS | S | SS | N | SS | S | SS | SS | S | SS | 1.00 | S | 10 |
| 31 | N | N | N | N | N | N | SS | N | SS | SS | N | SS | S | SS | SS | SS | S | N | SS | N | S | SS | SS | SS | S | 1.00 | 31 |
| | 7 | 15 | 21 | 22 | 25 | 29 | 30 | 35 | 36 | 12 | 19 | 20 | 26 | 32 | 34 | 39 | 6 | 16 | 17 | 18 | 27 | 38 | 2 | 9 | 10 | 31 | |

Key:
- SS = Correlations significant at the 0.01 level
- S = Correlations significant at the 0.05 level
- N = Correlations that are Not significant

@ Bounded rectangles are inter-correlations within each factor

**Appendix M8: Mathematics 2 (27.023) Mid-Semester 1, 2000 Test**

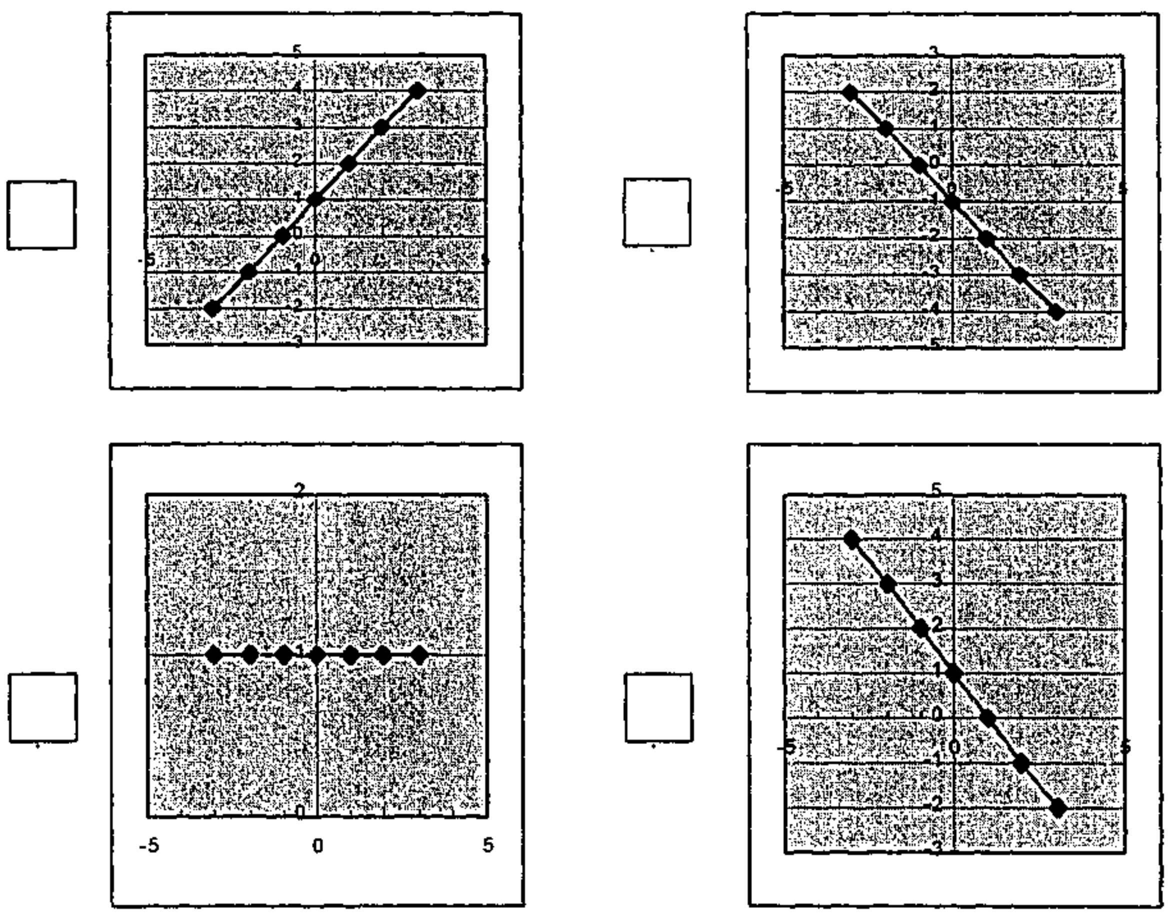
In each question circle the letter that corresponds to the correct answer.
Every question is worth a mark each.

**Please Attempt All Questions.**

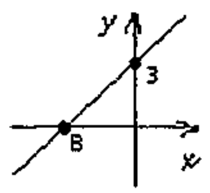
1. In the gradient-intercept form of the straight line equation **y = ax + b**, which of the letters in the equation represents the slope?

   **A.** b  **B.** ax  **C.** x  **D.** a

2. Which of the graphs below is that of the equation **y = 1 – x**



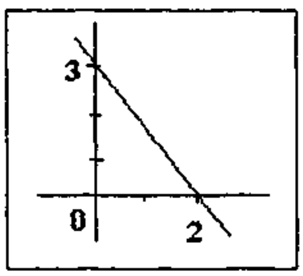
3. If the diagram below shows the line $y = x + 3$, what is the $x$ – value of the point B ?




A. -3 B. 0 C. 3

D. It cannot be worked out because insufficient information is given in the equation and the diagram.

4. The equation of the straight line in the diagram below is given by




A. $y = \frac{3}{2}x + 3$

B. $y = -\frac{2}{3}x + 3$

C. $y = -\frac{3}{2}x + 3$

D. It cannot be worked out because insuffcient information is given in the diagram.

5. Which of the statements below is true for the parallel lines

$$y = mx + a \quad \ldots\ldots\ldots\ldots (1)$$
$$y = mx + b \quad \ldots\ldots\ldots\ldots (2)$$
$$y = mx + c \quad \ldots\ldots\ldots\ldots (3)$$

and $a \neq b \neq c$

**A.** Lines (1), (2) and (3) have different gradients
**B.** Lines (1), (2) and (3) have the same y-intercept
**C.** Lines (1), (2) and (3) do not intersect at all
**D.** Lines (1), (2) and (3) are in fact the same line

6. Hooke's Law given by **E = 2W** describes the elongation in a spring due to weight applied to it.

If **E** is the elongation in centimetres and **W** is the weight in kilograms, what weight in kilograms would cause an elongation of 4cm?

**A.** $\frac{1}{2}$ kg **B.** 2 kg **C.** 4 kg **D.** 8 kg

7. Which of the following statements is true for a line with infinite ( $\infty$ ) slope ?

I. It is an horizontal line

II. It is a vertical line

III. It's equation is of the form $y = c$ where c is some constant number

IV. It's equation is of the form $x = c$ where c is some constant number

**A.** (II) only **B.** (I) and (IV) only

**C.** (II) and (III) only **D.** (II) and (IV) only

8. A line passing through the points (-4, 3) and (-1, -1) has slope equal to

A. $\frac{4}{3}$   B. $-\frac{4}{3}$   C. $\frac{3}{4}$   D. $\frac{4}{5}$

The following information refer to questions (9), (10) and (11).

The mid-point of $(x_1, y_1)$ and $(x_2, y_2)$ is given by $\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$.
A line $l$ passes through the mid-point of (2, 5) and (4, 7) and the midpoint of (-4, 3) and (-2, -1).

9. Which of the following pairs of points are definitely on the line $l$?

A. (3, 6) and (-3, 1)   B. (-1, 4) and (1, 3)

C. (2, 5) and (4, 7)   D. (-4, 3) and (-2, -1)

10. What is the gradient of the line $l$?

A. $\infty$   B. $\frac{5}{6}$   C. $\frac{3}{2}$   D. $-\frac{5}{6}$

11. What is the equation of line $l$?

A. $x = 3$   B. $5x - 6y + 21 = 0$

C. $5x + 6y - 21 = 0$   D. $3x - 2y + 7 = 0$

12. Which of the following equations is that of a line which passes through the midpoint of (0, 4) and (6, 6) and is parallel to the line $3y + x = 6$?

A. $y = -3x - 12$   B. $y = -\frac{1}{3}x + 2$

C. $y = -\frac{1}{3}x + 8$   D. $y = -\frac{1}{3}x + 6$

13. Which of the following statements about perpendicular lines are true.

(v) Any line with gradient 0 is perpendicular to any vertical line.
(vi) A line with gradient 0, passing through the point (2, 3) will also pass through the point (3, 2).
(vii) If two lines with gradients $\mathbf{m_1}$ and $\mathbf{m_2}$ are perpendicular then $\mathbf{m_1} \times \mathbf{m_2} = \mathbf{-1}$ is true.
(viii) The gradient of a line **h** is $-\frac{1}{2}$ therefore the gradient of a line perpendicular to **h** is 2.

**A.** (i), (ii) and (iii) only  **B.** (ii), (iii) and (iv) only

**C.** (i), (iii) and (iv) only  **D.** All of them

14. At which point do the lines $2x + 3y + 7 = 0$ and $5x - y - 8 = 0$ intersect ?

**A.** (2, 3)  **B.** (1, -3)  **C.** (-1, 3)  **D.** (5, -1)

15. A lever is balanced on a fulcrum with weights of 15 kg at one end and 25 kg at the other. The lever is still balanced when a 5 kg weight is added to the 15 kg weight if the 25 kg weight is moved 2 cm farther from the fulcrum.

If we let x centimetres represent the distance from the 15 kg weight to the fulcrum, and y centimetres to represent the distance from the 25 kg weight to the fulcrum, which of the following pairs of equations represent the situation algebraically ?

**A.** $15x + 25y = 0$
$20x + 25y = -50$

**B.** $15x - 25y = 0$
$20x - 25y = 50$

**C.** $15x + 25y = 0$
$15x + 25y = 50$

**D.** $15x - 25y = 0$
$15x - 25y = -50$

16. Raka's age is 7 years less than twice Kila's age. Together their ages add to 8 years. If **x** represents Raka's age and **y** represents Kila's;

Which of the following statements are true?

| | |
|---|---|
| **(i)** | $x + y = 8$ |
| **(ii)** | $x = 7 - 2y$ |
| **(iii)** | $x = 2y - 7$ |
| **(iv)** | Kila is younger than Raka |
| **(v)** | Kila is older than Raka |

| | |
|---|---|
| **A.** | (I), (II) and (IV) only |
| **B.** | (I), (III) and (IV) only |
| **C.** | (I), (III) and (V) only |
| **D.** | (1), (II) and (V) only |

17. Given that **b** = $\sqrt{x^2 - a^2}$ , then **a** =

A. $x^2 - b^2$ **B.** $\pm \sqrt{x^2 - b^2}$

C. $\pm \sqrt{x^2 - b}$ **D.** $\pm \sqrt{x - b}$

18. If $\mathbf{x = 5}$ and $\mathbf{y = -2}$ then the value of the algebraic expression

$\mathbf{xy^2 - x^2y}$ is:

A. 210 **B.** 200 **C.** 70 **D.** -30

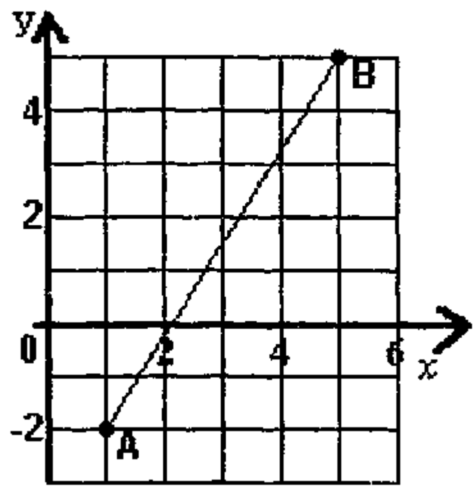
19. The formula for calculating simple interest is $\mathbf{I = \frac{PRN}{100}}$ , where

**P** = Principal sum invested
**N** = Number of years the principal sum is invested
**R** = Percentage Rate at which the principal sum is invested

At what percentage rate should a principal sum of **K 540.00** be invested for $3\frac{1}{2}$ years to earn an interest of **K 113.40** ?

A. 7 % B. 6 % C. 5% D. 4 %

The information in the diagram below refers to questions 20 and 21 .




The coordinates of the two opposite vertices of the rectangle are (1, -2) and (5, 5) as shown in the diagram.

20. What is the length of the diagonal **AB** of the rectangle to the nearest whole number?

A. 9 B. 8 C. 7 D. 5

21. What are the coordinates of the two other vertices of the rectangle ?

A. (1, 5) and (5, -2) B. (0, 5) and (6, -2)

C. (2, 5) and (4, 2) D. (1, 4) and (5, -1)

22. $W = \frac{1}{2}mv^2 + mgh$. If $v = 6$, $m = 2$, $W = 1996$ and $g = 980$. Which of the following is the value for h ?

A. 1 B. 2 C. 3 D. 4

23. Given that $A = P\left(1 + \frac{r}{100}\right)$, then r =

A. $100\left(\frac{A+P}{P}\right)$ B. $100\frac{A}{P} - 1$

C. $100\left(\frac{A-P}{P}\right)$ D. $100(AP - 1)$

24. The distance in metres a stone falls from rest after t seconds is given by the formula $d = \frac{1}{2}gt^2$ where g the acceleration due to gravity is $9.8\ ms^{-2}$. What distance (to the nearest whole number) is covered after 2 seconds ?

A. 40 m B. 30 m C. 20 m D. 10 m

25. When expanded $(x - 2)(x + 3) =$

A. $x^2 - x - 6$ B. $x^2 - x + 6$

C. $x^2 + x - 6$ D. $x^2 + 5x - 6$

26. When factorized $3x^2 + x - 10 =$

A. $(3x - 10)(x + 1)$ B. $(3x + 10)(x - 1)$

C. $(3x - 5)(x + 2)$ D. $(3x + 5)(x - 2)$

27. What is the lowest Common denominator of the algebraic expression

$\frac{7x}{2x^2 - 18y^2} - \frac{3}{5x + 15y}$ in simplest factor form ?

A. $10(x^2 - 9y^2)(x + 3y)$ B. $10(x^2 - 9y^2)$

C. $10(x + 3y)$ D. $10(x + 3y)(x - 3y)$

28. Which of the following is the simplest form of the algebraic fraction

$$\frac{a^2 + 2ab + b^2}{a^2 - b^2} \ ?$$

A. $\frac{1+2ab+1}{1-1}$

B. $\frac{a+b}{a-b}$

C. $\frac{a+b}{a+b}$

D. $\frac{(a+b)^2}{(a-b)^2}$

29. Which of the following gives the most simplified form of the expression

$3(x-5)^2 - 2(x-5)(x+5) - (90-17x)$

A. $x^2 - 47x - 35$

B. $x^2 - 47x + 35$

C. $x^2 - 13x - 35$

D. $x^2 - 13x + 35$

30. Which of the following is the most simplified form of the algebraic expression

$$\frac{u^2-1}{3} \div \frac{u+1}{6}$$

A. $\frac{2(u^2-1)}{u+1}$

B. $\frac{(u+1)^2(u-1)}{18}$

C. $2(u+1)$

D. $2(u-1)$

31. What are the two binomial factors of the quadratic equation $\mathbf{x^2 - x - 20 = 0}$

A. $(x-5)$ and $(x+4)$

B. $(x+5)$ and $(x-4)$

C. $(x-10)$ and $(x+2)$

D. $(x+10)$ and $(x-2)$

32. At which point does the linear equation $2x + y + 2 = 0$ meet the parabola

$y = 2x^2 - 6x$ ?

A. (1, 0) B. (1, 4) C. (1, -4) D. None of these

33. Look at the following statements about parabolas and decide which of the following statements are true and which are not ?

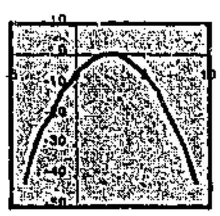
VI. The vertex of a parabola is the point around which the graph curves.
VII. The line of symmetry goes through the vertex.
VIII. All parabolas of the form $y = ax^2 + bx + c$ have strictly 2 solutions.
IX. All parabolas have at least one solution.
X. The parabola $x^2 - 5x + 6$ has a least value.

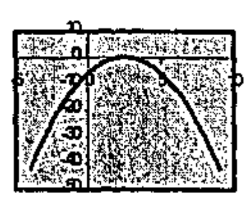
The true statements are;

A. I, II and III only B. I, III and IV only

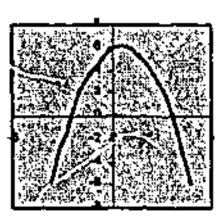
C. I, II and V only D. All of them

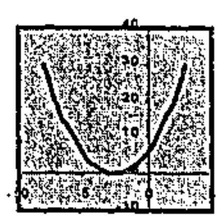
34. Which graph below is most likely showing the parabola $y = x^2 + x - 6$.



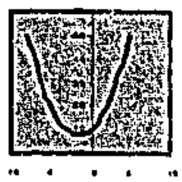


B



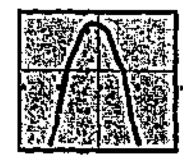


The graphs below refer to questions 35, 36, 37 and 38

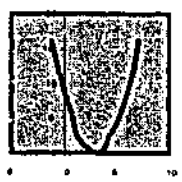


I

II



III



IV

V

VI

35. The general quadratic equation is given by $y = ax^2 + bx + c$.
**Which of the graphs above show the situation where $a < 0$**

A. II, III and VI only

B. II and III only

C. III, IV and VI only

D. I, IV and V only

36. Which graphs show parabolas with no solutions ?

A. II and IV only

B. III and V only

C. I and VI only

D. VI only

37. Which graphs show parabolas that are most likely to have only one solution ?

A. I and VI only

B. II and IV only

C. III and V only

D. VI only

38. Which graphs show parabolas that have two solutions ?

A. I and VI only

B. II and IV only

C. III and V only

D. VI only

39. A rectangular piece of sheet metal is 3m longer than it is wide. The area of the piece of sheet metal is $28\ m^2$.

What are its dimensions?

A. Length = 6 m, Width = 3 m

B. Length = 7 m, Width = 4 m

C. Length = 7 m, Width = 3 m

D. Length = 10 m, Width = 7 m

40. Which of the following are the solutions for $p^2 - 3p = 40$ ?

A. $p = 8$ or $-5$

B. $p = 8$ or $5$

C. $p = -8$ or $5$

D. $p = -8$ or $-5$

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