Chapter 1

INTRODUCTION

Identification of the Problem

During the last ten years mathematics research has focussed on how students learn mathematics, the content of the mathematics curriculum and the attitudes of teachers and the community towards the mathematics content of the curriculum.

The national reports into mathematics education and published research in the United States of America (NCTM 1980; Dessart and Hembree 1986), the United Kingdom (Mathematics Counts 1982; Shuard 1986; CAN 1989) and Australia (AMEP 1982; Blane and Willis 1986; Willis 1990; AEC 1990) during this time have generated much discussion amongst mathematics educators and curriculum developers as to the direction of change for mathematics education. This direction of change has focussed on the appropriate mathematics content to be taught in schools and the investigation of effective strategies to be used in the teaching and learning of mathematics from Kindergarten to Year 12.

Changes in mathematics education have been evident across the world (Carss 1985; Malone 1989; PriME 1989; NCTM 1989) and throughout Australia (NSW Department of School Education 1989; AEC 1990) with:

- the growing emphasis and acceptance of problem solving as the focus for the teaching and learning of mathematics;

- the availability of concrete materials for students' use;
• the emphasis on practical experiences in encouraging students to construct their own mathematics knowledge;

• recognition of the importance of students developing mental strategies when doing mathematical calculations;

• the introduction of computers and calculators into the mathematics classroom;

• recognition of the importance of the verbal and written language in mathematics and a greater emphasis on the teaching of geometry.

Reys and Reys (1987) suggest that of these changes one that "a growing number of people recognise"(p.12) as having significant implications for the primary school mathematics curriculum is that of the introduction of calculators. The ease of access and reduced cost of calculators together with their increased availability to the general community have had and are still having an effect on both the content of the school mathematics curriculum and on the teaching of mathematics.

In Australia in recent times, the student use of calculators has been recommended from the earliest school years (CDC 1987; NSW Department of School Education 1989; AEC 1990). Yet at the same time, controversy continues within the community about its use by students in the primary mathematics classroom (Blane, 1986).

The purpose of this study was to investigate primary teachers' attitudes toward the student use of calculators in primary (Kindergarten to Year 6) mathematics classes.
Chapter 2

LITERATURE REVIEW

Introduction

The purpose of this study is to investigate primary teachers' attitudes toward the student use of calculators in primary (Kindergarten-Year 6) mathematics classes. This is one aspect of the broader question of the use of calculators in primary mathematics classrooms. Within the literature it is necessary to review significant policy changes in the student use of calculators and to consider the findings of critical research on the use of calculators in mathematics classes that have occurred over the last 25 years.

The focus of this review is on the issue of calculator use as reported in the United States of America, the United Kingdom and Australia. The review is presented in four sections:

Section One: The Calculator Issue — Internationally
Section Two: Critical Research on the Student Use of Calculators
Section Three: The Perceived Role of Calculators in the Mathematics Classroom
Section Four: Implications for the Curriculum

The first section, The Calculator Issue: Internationally, analyses the direction that the United States of America, the United Kingdom and Australia have set for the student use of calculators in mathematics classrooms. This section also considers the continuing controversy within the community that surrounds the use of calculators in mathematics classes.
The second section **Critical Research On The Student Use of Calculators** reviews research on the effects of the use of calculators in mathematics classes and the attitudes of various groups towards their use. Specific comment is given to the findings of the Calculator-Aware Number curriculum study carried out in the United Kingdom from 1986 to 1989 as part of the Primary Initiatives in Mathematics Education (PrIME) Project.

The third section **The Perceived Role of Calculators in the Mathematics Classroom** presents arguments which highlight the various roles in which the calculator can be used in mathematics classes.

The fourth section centres on **Implications for the Curriculum** discussing the need for curriculum change brought about by the use of calculators and the support needed to implement effective curriculum change.
Section One: The Calculator Issue — Internationally

The electronic calculator has a relatively short history. In 1965 the first electronic calculator was produced. (Moursund, 1981, p.6)

During the 25 years since the first calculator was produced the use of calculators in both primary and secondary mathematics classrooms and the place of calculators in the mathematics curriculum have been dominant issues in mathematics education. These curriculum issues have continued to arise as calculators have become increasingly available to schools and students.

For more than ten years, researchers in the United States of America (Bitter, 1980; Moursund, 1981), United Kingdom (Bell et al, 1983; Fitzgerald, 1988; Shuard, 1989) and in Australia (Koop, 1979; Blane & Willis, 1985) have noted the increasing ease of access to calculators for children in our schools and their wide availability in the community. It has been commented that "hand held calculators are rapidly becoming part of the everyday environment of both adults and children" (Koop, 1979, p.6) and that "wide and rapid spread of ownership is already a fact in most advanced countries..." (Bell et al, 1983, p.307)

At the Fifth International Congress on Mathematics Education (ICME 5) an action group focussing on Calculators reported that:

In the USA in 1982, 75% of grade 5 students had access to calculators and in 1983-84 87% of grade 5 students in the UK had calculators available. In a study in 1983 in New South Wales, Australia, 40% of grade 5 students used calculators in the classroom, the highest percent found so far in any study. (ICME 5, 1984, p.69)
At the same conference (ICME 5) the issue of the place of calculators in the mathematics curriculum was highlighted in a report from The Technology Working Group.

There are many countries where more than 80% of children have calculators available, yet the school curricula ignore the existence of calculators or calculator use in mathematics education is not allowed in many grades. (ICME 5, 1984, p.162)

The report stressed that "research evidence supports the use of calculators at all levels, indicating that achievement will not be harmed and may be enhanced when calculators are used" (ICME 5, 1984, p.33).

Internationally, over the last ten years a dominant issue in curriculum change amongst educators and the community has been the place of the calculator in mathematics classrooms. With the increasing availability of calculators and the research support for the use of calculators at all year levels, particular focus is to be given to a review of the policies on the use of calculators in primary mathematics classes in the United States of America, the United Kingdom and Australia.

In the United States of America

In 1980 the National Council for Teachers of Mathematics (NCTM) published its Agenda for Action. This was seen for schools in the 1980's as a national direction statement for mathematics education in the United States. It had as Recommendation 3:

That mathematics programs take full advantage of the power of calculators and computers at all grade levels. (NCTM, 1980, p. 8)
In the late 1970's calculators were being purchased by the majority of households and as evidenced by the NCTM's recommendation the issue of the place of the calculator in mathematics classes was high on the agenda for change in mathematics education. Within a period of 15 years Moursund (1981) was writing that "the electronic calculator has become readily available. Common estimates are that a calculator can be found in about 95% of the homes in the United States and that 30 million are purchased annually" (p. 3).

In reflecting on these times Kansky (1987) wrote that "most supported the use of the calculator... calculator workshops were all the rage at NCTM meetings... textbooks at all levels included calculator-related problems. Talk was even heard of a K-12 'calculator based mathematics curriculum' to be constructed" (p.4).

Yet the use of calculators was not taken up by schools. As discussed in more detail under The Calculator Controversy (p.31), many teachers and parents considered that student use of the calculator would inhibit children's mathematical skills (Open University, 1983; Leechford and Rice, 1982; Del Campo, 1986).

There was continued support from the NCTM for the use of calculators in all grades from Kindergarten and in 1987 the NCTM again reiterated its policy towards the use of calculators. It stated that the council recommends the integration of the calculator into the school mathematics program at all grade levels in classwork, homework, and evaluation. At each grade level every student should be taught how and when to use the calculator. (NCTM, 1987, p.61)
In discussing this recommendation Coburn (1987) believed that children should have access to calculators and that calculators should be made available in the school's mathematics curriculum.

This recommendation urges that students be provided access to calculators and that calculator use be integrated into the core mathematics curriculum on a routine basis. (p.1)

Not only the NCTM supported the use of calculators in the mathematics curriculum so too did state educational authorities, as evidenced by The Mathematics Framework for California Public Schools Kindergarten through Grade 12 which was approved in 1985. This framework made a strong statement on the use of calculators in the mathematics program.

Calculators are used pervasively because of their efficacy in computation. For this reason and because of their value in the teaching and learning of mathematics, calculators must be incorporated in the school's mathematics program. (California State Department of Education, 1987, p. 64)

In March 1989, the Curriculum and Evaluation Standards for School Mathematics was published in America. These standards were "designed to establish a broad framework to guide reform in school mathematics in the next decade" (NCTM, 1989, p. v). This document had as one of its beliefs that "appropriate calculators should be available to all students at all times" (NCTM, 1989, p. 8) and also that "calculators must be accepted at the K-4 level as valuable tools for learning mathematics" (NCTM, 1989, p.19).

However, the publication did not state what the appropriate calculators were for each child. There was also no indication given regarding how they were to be used within the class or what skills, if any, needed to be taught for their effective introduction into primary mathematics classes.
In the United States of America during the 1980’s there had been strong support from the NCTM and educational authorities for the use of calculators in all grades from Kindergarten. Support for such a view was expressed in the United Kingdom with the publication of Mathematics Counts (1982), a report of an inquiry into the teaching of mathematics at all educational levels.

In the United Kingdom

The Report of the Committee of Inquiry into the Teaching of Mathematics in Schools (1982) published in the United Kingdom focussed on all aspects of mathematics education from pre-school to the workplace. Titled Mathematics Counts, the report stated that "it is right that primary teachers should allow children to make use of calculators for appropriate purposes" (Cockcroft, 1982, p. 113).

As to what these appropriate purposes were the report does not say, for the committee believed that:

more is needed both to consider the use of calculators as an aid to teaching and learning within the primary school mathematics curriculum as a whole and also the extent to which the arithmetical aspects of the curriculum may need to be modified. (Cockcroft,1982, p. 113)

Baker (1982) reported that a survey carried out by HM Inspectors of Schools in 1978, focussing on mathematics in the primary school, "makes no mention of calculators" (p.162). Baker believed that this survey, together with work being carried out by the Shell Centre in Nottingham, "indicates that many teachers are not yet aware of the vast potential of calculators in the primary classroom" (p.162).
The relevance of this survey became apparent when one considered that four years later there was strong support for the availability of calculators for appropriate purposes in primary schools. Baker believed that teachers were unaware of how calculators could be used.

Indeed, during this study, it has become increasingly clear that teachers have little, if any, acquaintance with the positive aspects of calculator use such as:

- stimulation and motivation,
- improved attitudes and confidence,
- the practice and reinforcement of skills,
- its diagnostic potential,
- tool for investigations. (Baker, 1982, p.162)

With the emergence of the National Curriculum in the United Kingdom calling "for children to be able to calculate mentally, with pencil-and-paper and with a calculator" (PrIME, 1989, p.9), study was needed to determine an effective way in which each of these methods of calculation could be introduced into the primary mathematics curriculum. A major project was initiated in 1986 to investigate primary mathematics; one aspect of this project comprised the use of calculators in primary classrooms. This project, titled the Primary Initiatives in Mathematics Education (PrIME), incorporated the Calculator-Aware Number (CAN) curriculum.

The tasks of this project appear to be orientated towards those outlined in Mathematics Counts (1982):

more is needed both to consider the use of calculators as an aid to teaching and learning within the primary school mathematics curriculum as a whole and also the extent to which the arithmetical aspects of the curriculum may need to be modified (para 388).

The results of CAN (1989) as reported to date, are discussed in more detail in Section Two of this review.
During the 1980's in both the United States of America and the United Kingdom there had been strong support for the use of calculators in primary mathematics classes. A similar situation existed in Australia.

In Australia

The support for the use of the calculator in Australia appears to have originated in the early 1980's with the publishing of the list of 'Basic Mathematical Skills and Concepts for Effective Participation in Australian Society' developed by the Australian Mathematics Education Project (AMEP, 1982). This list of basic skills had stated under the heading Number Skills and Computational Skills that "to be effective citizens, students need basic skills in number and computation, including the capacity to use a calculator appropriately" (AMEP, 1982, p.2).

There was no statement elaborating on how teachers were to incorporate calculators into their teaching, nor was there a clear statement concerning their place in primary mathematics classes. Over the next four years little information on the use of calculators in mathematics classes was published. Then in 1986 a major survey sponsored by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) recommended the need for a national policy statement in Australia for the use of calculators in mathematics classes.

UNESCO/CDC Report

In 1986 Blane and Willis presented a report on the applications of calculators to the teaching of mathematics in Australia. This report, sponsored by UNESCO, was titled 'Report On The UNESCO Pilot Project On The Applications Of Calculators To Mathematics Teaching In Australia' and
focussed on the 12-14 age group. However the Curriculum Development Centre (CDC) in Canberra wished to elicit some response from primary schools on their use of calculators and some information on the situation in primary schools was collected. However, due to the emphasis of the project the report focussed on the lower secondary classes.

In the process of the study questionnaires were sent to "300 schools in three States and two Territories" (Blane & Willis, 1986, p.3). There were 372 questionnaires returned: 175 from primary schools and 197 from secondary schools. The authors stated that "despite clear statements from State and Territory Education Departments in Australia, there still appears to be a great deal of confusion about whether, when and how calculators should be used in Australian mathematics classrooms" (Blane & Willis, 1986, p.6).

They further reported that "there have been some surveys on the use of calculators in school mathematics classes in Australia, but few have been published, and information on this topic is comparatively sparse" (Blane & Willis, 1986, p.8).

Following is a summary of findings on various issues from Blane and Willis' (1986) report relevant to the present study.

**Attitudes to Calculators**

In reporting on the attitudes of students, parents and teachers in lower and upper secondary classes to the use of calculators Blane and Willis (1986) reported that:

Students were rated as being strongly in favour of the use of calculators ... Parents were thought to be strongly opposed and very few strongly in favour. Teachers, however, seemed to be fairly evenly spread on this issue but with a comparatively high percentage against the use of calculators in mathematics in this age range (p.7)
At the Upper Primary level it was found that students were "seen to be strongly in favour of the use of calculators, whereas the parents were perceived to be strongly against. Teachers were again spread..." (Blane & Willis, 1986, p.8). The findings suggested that whereas some parents were in favour of calculators in secondary classes that support was not in evidence at the primary level.

**Calculator Use in Mathematics Lessons**

One of the questions asked how often students use calculators in mathematics lessons. It was found that in the Lower Secondary level there were a number of students "who were never allowed to use calculators in mathematics lessons in Year 7 (25%) and Year 8 (15%) but there was a dramatic change in Year 9 (3%), when nearly all pupils were allowed to use a calculator, at least sometimes" (Blane & Willis, 1986, p.10).

However, in the Upper Primary level, "it appears that there was a much greater use of calculators, at least 'sometimes', compared to the use in Year 7" (Blane & Willis, 1986, p.11).

**Age for First Using Calculators**

In gathering data on the appropriate age for students to be using calculators Blane and Willis (1986) found that "the modal age at which it was considered most appropriate to use calculators in mathematics classes was '14', that is in Year 9 of schooling in Australia" (p. 12). They suggested that this indicated a resistance among secondary teachers to the introduction of the calculator "in mathematics classes during the first two years of secondary schooling in the 12-14 age range" (Blane & Willis, 1986, p.12).
Use Made of Calculators

Blane and Willis (1986) concluded that:

In general it seemed that calculators were used in the more obvious areas as a calculating device, rather than as a teaching aid to help with understanding and exploration of mathematical concepts, to help overcome misunderstandings and difficulties, and for promoting interest and enrichment. While there was strong agreement that these should occur it appeared that there was a significantly strong resistance to their adoption or an inability to implement their use in this way. (p.15)

In summary, "the survey found that there appeared to be little research and development taking place in this critical area of mathematics education in Australia" (Blane & Willis, 1986, p.27). The authors concluded that, "a statement on the policy for using calculators in school mathematics is seen as an essential pre-requisite which should come from the highest educational level" (Blane & Willis, 1986, p.28). By 1987 this was the case with the release of "A National Statement on the use of Calculators for Mathematics in Australian Schools".

At the time of the release of the UNESCO/CDC report the Commonwealth Government of Australia had given the states monies for the Basic Learning in Primary Schools (BLIPS) program. This money was to be used by each state in the development of curriculum materials and professional development materials for teachers and the community in the areas of literacy and numeracy. Each state was evaluating the importance of literacy and numeracy in primary schools in the context of changing societal needs.

One aspect of numeracy being discussed and investigated was the place of calculators in primary mathematics classes. The N.S.W. BLIPS numeracy team released a discussion pamphlet titled 'Calculators in the Primary School - a pressing concern' (1986) that outlined many of the arguments for and against the use of calculators in primary classrooms. The BLIPS
program, the report by Blane and Willis (1986) and the overseas research all contributed to the development of a national policy statement on the use of calculators in Australian schools.

**National Policy Statement on the Use of Calculators**

The release in 1987 of "A National Statement on the use of Calculators for Mathematics in Australian Schools", a joint statement from the Curriculum Development Centre (CDC) and the Australian Association of Mathematics Teachers (AAMT), had as its first recommendation that teachers should:

"ENSURE THAT ALL STUDENTS USE CALCULATORS AT ALL YEAR LEVELS (K-12)."

This statement was endorsed by all State and Territory Departments of Education and the National Catholic Education Commission. Here was a clear direction being given by national curriculum planners that calculators were to be part of the primary as well as the secondary mathematics curriculum. However, three years after the release of this national policy the Discipline Review of Teacher Education in Mathematics and Science reported that even though:

> A national statement on the use of calculators has been given wide circulation and has been acted on in many places. There is, nonetheless, still sufficient lack of awareness of, and in some cases antagonism towards, the use of calculators in teacher preparation for it to be of serious concern. The use of calculators in the classroom enables a greater emphasis to be placed on mathematics which is exciting and challenging, rather than on tasks which are dull, repetitive and boring. Strategies for teaching mathematics should include the application and use of the calculator which facilitate the construction of mathematical knowledge. (Discipline Review Report [Vol. 1], 1989, p.25)

There was evidence that the national policy on calculator use which recommended their classroom use from Kindergarten may not have been taken up by teachers in the classroom. The Discipline Review (1989)
expressed concern that teachers were unaware of how to use calculators in the mathematics classroom and that there still existed a divergence of opinion amongst teachers as to when they should be used.

**Discipline Review of Teacher Education in Mathematics and Science**

The Discipline Review of Teacher Education in Mathematics and Science (1989) evaluated the current situation of mathematics and science education in Australia. In a survey report to the Review, the Federation of Australian Scientific and Technological Societies (FASTS) and the Australian Association of Mathematics Teachers (AAMT) stated that:

> Calculators are in use in most (87.6%) schools, particularly in government schools (92.5%) and non-systemic schools (93.1%). There is less use made of them in Catholic schools (76.3%). Their use is mainly in structured lessons (96.9%) rather than free use. However, only 46% of schools provide calculators, the remainder rely on students to bring them. (F.A.S.T.S., 1988, p.3)

There were not sufficient details in the report on the structure of the survey to be able to fully explain these comments. However, there was an indication that the use of calculators was increasing in schools and that the increase in the use of calculators would have an effect on the content of teacher development courses. This view was voiced by Willis and Kissane:

> pre-service teachers must have the opportunity to become familiar with the technology themselves, not as observers or even through set exercises but by exploring mathematical questions of interest to themselves. In the case of prospective primary teachers, the calculator should be regarded as the major mathematical tool. (Willis and Kissane, 1989, p.89)

In evaluating teacher pre-service courses the Review Panel asked students to indicate how prepared they felt for teaching various aspects of mathematics. Each aspect was rated by students according to a four-point scale.
the Review Panel took the position that a mean rating of less than 2.5 on the four-point scale used represented poor quality, that a mean rating in the range of 2.5 to 2.75 represented marginal quality, in the range of 2.75 to 3.0 was acceptable with respect to quality, and above 3.0 as good or excellent. (Discipline Review Report [Vol. 2], 1989, p. 31)

One of these aspects was calculator computation based methods. From the 2,814 responses by students who were completing their Diploma of Teaching/Bachelor of Education, a mean of 2.62 was gauged. This 2.62 mean could be interpreted as marginal quality. For students involved in Early Childhood Courses the response was 1.74 and those in their Diploma of Education (Primary) 2.33. In both cases this would indicate that the students felt they had a poor level of knowledge in calculator computation based methods (Discipline Review Vol. 2, 1989, p.56 Table 2.13).

In presenting their report, the Discipline Review Panel commented that:

> the national policy on calculators...requires their inclusion in primary mathematics. The Review Panel urges the use of calculators in mathematics education to teach concepts, to eliminate wasteful repetitive pencil-and-paper activities, to encourage the exploration of numbers, to be used for checking and estimating, and for making the study of mathematics exciting, stimulating and non-threatening (Discipline Review Report [Vol. 1], 1989, p. 69)

The evidence overall from the Review thus indicated that students felt they were being only "marginally" prepared to introduce calculators into the mathematics classroom.

**National Statement of Principles for Mathematics in Australian Schools**

The distribution by the Australian Education Council (AEC) of the draft of 'A STATEMENT OF PRINCIPLES FOR MATHEMATICS IN AUSTRALIAN SCHOOLS' (1990) added further support to the introduction of and compulsory use of calculators by all students from Kindergarten to Year 12.
It should be taken for granted that a calculator is available whenever it can profitably be used, from K-12. A number of skills, both conceptual and technical, underlie the correct use of a calculator and these should be taught explicitly. (AEC [Draft], 1990, p.44).

This statement, supported by all Ministers of Education from Australian States and Territories, was seen as a national framework "to be used by all Australian education systems as a guide and reference when they write new mathematics syllabuses or revise existing ones" (AEC [DRAFT], 1990, preface).

However, the National Statement’s emphasis on the availability of the calculator for students from Kindergarten may not have the support of teachers. Already it has been shown in the Discipline Review (1989) that teachers may be unaware of how to implement the use of calculators and that some teachers were antagonistic towards their use in primary mathematics classes. Evidence needs to be collected to ascertain more accurately teacher attitudes towards the student use of calculators. Research projects such as the Calculator-Aware Number study need to be completed and complemented in order that teachers and curriculum designers be made aware of how best to use calculators in the teaching of mathematics and how to best incorporate them into the mathematics curriculum.

A Focus on New South Wales
Curriculum change in the NSW Department of School Education during the 1980's was based on a ten-year cycle. The first stage of this cycle was a planned evaluation of the already existing situation with regard to the mathematics curriculum. One aspect of the evaluation involved the administration of a survey to practising teachers concerning issues related to mathematics education. This survey, titled 'The Report on the Evaluation of The Primary Mathematics Curriculum', carried out by the N.S.W.
Department of School Education in 1982-84, reported the results of teacher response to a survey sent to a random sample of 2,189 teachers in November 1982. The response rate to the survey was 65% (1,429 teachers responded).

Question 16 of the survey titled "Inclusions in Future Curriculum Document", sought teacher opinion to the role of the calculator in the classroom

<table>
<thead>
<tr>
<th>ASPECTS</th>
<th>ESSENTIAL</th>
<th>DESIRABLE</th>
<th>NOT NECESSARY</th>
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<tbody>
<tr>
<td>The role of calculators in the classroom</td>
<td>338</td>
<td>658</td>
<td>379</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>48%</td>
<td>28%</td>
</tr>
</tbody>
</table>

(NSW Department of Education, 1984, Question 16)

The results indicated that 73% of these teachers considered the inclusion of calculators in the primary school as 'Essential/Desirable' and that 28% considered the role of calculators in the classroom as being 'Not Necessary' for inclusion in a future curriculum document. This indicated that there were then a number of teachers not supportive of the use of calculators in primary classes.

Section 2.12 of the Report asked teachers "to comment on any other aspects that they considered essential for inclusion in a central Mathematics K-6 Curriculum" (NSW K-6 Mathematics Evaluation Report, 1984, Appendix 5). An analysis of the responses found that "the major area for inclusion was the application of computers and electronic media" (NSW K-6 Mathematics Evaluation Report, 1984, Appendix 5).
No information was gathered regarding teachers' attitudes towards the role of calculators in the primary classroom, with respect to:

- **when** they should be introduced,
- **how** they were then being used, or
- **how** they could be used.

In 1986 the NSW Department of School Education continued the discussion of the role of calculators in primary schools with the release of the discussion paper titled 'Calculators in the Primary School - a pressing concern' (BLIPS, 1986). This discussion paper stated that the BLIPS team and the K-6 Mathematics Curriculum Project Team are investigating ways of incorporating into the future syllabus and BLIPS program materials, ideas for using calculators to enhance pupils:

- concept development
- skill development and reinforcement
- problem solving
- attitudes. (BLIPS, 1986, p. 4)

The NSW K-6 Mathematics Syllabus was released in 1989. In the same year the NSW Department of School Education, in its document titled 'Equity and Excellence' (1989), gave the following comment on the syllabus:

The Mathematics K-6 syllabus has clear aims and gives proper emphasis to learning the basic facts and operations of mathematics including the memorisation of tables. It also advocates approaches which will assist students to develop more positive attitudes towards mathematics. It recognises the importance of students understanding mathematics as well as computational ability. Its successful implementation will foster a future generation well equipped to handle technological change and to deal confidently with mathematical problems in everyday life. (p.20)

It made no direct comment about the use of calculators in primary school, though the NSW Department of School Education in its Mathematics K-12 Statement of Principles (1989) supported the use of calculators and stated the implications for teaching with their introduction into primary and
implications for teaching with their introduction into primary and secondary schools. The K-12 Statement of Principles was the underlying rationale for the teaching and learning of mathematics in NSW schools.

One of its stated principles was:

Mathematics learning is promoted by the appropriate use of a variety of materials, equipment and personnel.

(NSW Department of School Education, 1989, p.4)

The stated implications for this principle were:

- The availability of technological equipment, such as calculators and computers, does not reduce the need for mathematical understanding or the need for competence.

- Some concepts and skills need to receive greater emphasis with the introduction of calculators and computers, e.g., place value and decimal concepts; skills of approximation and estimation.

(NSW Department of School Education, 1989, p.4)

The NSW K-6 Mathematics Syllabus has, as one of the stated aims:

To develop in students an appreciation of the applications to mathematics of technology, including calculators and computers.

(NSW Department of School Education, 1989, p.8)

The document titled 'Excellence and Equity: New South Wales curriculum reform' (NSW Ministry of Education, 1989) was a review of the syllabus structure and directions within N.S.W. State Education. This review included the K-6 Mathematics Syllabus that supported the student use of calculators.

Within the 'Excellence and Equity' document no mention was made concerning the community controversy regarding the use of calculators in mathematics classes. The document made specific mention to the
importance of memorisation of tables; this issue of children's knowledge of the basic facts has been at the very centre of the calculator controversy, arising from a reported community concern that children will become dependent on the use of calculators and not know their basic mathematical facts (Cockcroft, 1982; Del Campo, 1986).

The Calculator Controversy

Since the development of the calculator, controversy has simmered within the community concerning whether or not calculators should be used at all by students in schools. It appeared from reviewing the major policy statements in the United States of America, the United Kingdom and Australia during the 1980's and now into the 1990's that there was strong support amongst educational authorities for the use of calculators from Kindergarten to the end of school. Yet over this time writers have observed that schools have not made calculators readily available to all students and their place in the mathematics curriculum continues to be debated. Willis and Kissane (1989) supported the view that "calculators and computers have been in schools for at least a decade with little or no noticeable effect on the mathematics curriculum" (p.75).

Arguments Against Calculator Use

Cooper and English (1985) had earlier suggested that it was due to a distrust by teachers and parents that calculators had not had the impact on the mathematics class that had been expected in the 1980's.

Inexpensive hand-held calculators have been around for quite some time. However, there still exists considerable distrust of their value in the classroom and their actual use is very limited in many schools....This seems to stem from the view of many teachers and parents that calculators only give answers and hence are simply a replacement for computation. (p.31)
Perry (1989) writing on the issue in early childhood mathematics supported this view.

The advent of the electronic calculator has had only a minimal effect on mathematics education in primary schools and early childhood settings, although this is slowly changing. However, there is still a deal of antagonism from these settings with feelings that the introduction of such technology will lead to a generation of innumerate children. (p.162)

The view that antagonism still existed among teachers towards the use of calculators was supported by McIntosh (1990) when he wrote that "some may allow it for checking calculations and a few for some games of making words by turning the calculator display upside-down but by and large it is shunned as a dangerous and potentially debilitating beast" (p.25).

It was evident from the literature that such a view had existed within the community on the student use of calculators in schools for quite some time. This controversy had been discussed in Mathematics Counts (1982).

It is also clear that there is widespread public concern about the use of calculators by children who have not yet mastered the traditional paper and pencil computation. It is feared that children who use calculators too early will not acquire fluency in computation nor confident recall of basic facts. (p.110)

In a later study Del Campo (1986) reported:

Recent surveys carried out in Victoria indicate that a large majority of parents, teachers and school children believe that calculators should not be used in primary schools. There is a widespread fear that many children who use calculators will become overdependent on them and will therefore not learn their basic facts. (p.240)

It has been this fear of children not knowing their basic facts and becoming dependent on the calculator that has led some members of the community to not supporting the student use of calculators in mathematics classes.
"One of the most complex, controversial issues in mathematics education today is the use of hand-held calculators in schools" (Shult, 1981, p.181). The major concern with students using calculators "in the primary school - expressed by teachers, parents and children - is that they 'rot the brain'" (Open University, 1983, p.19). A further concern reported by Leechford and Rice (1982) was that of students losing their basic skills of addition, subtraction, multiplication and division if they became dependent on calculators.

The controversy surrounding the use of calculators in the mathematics classroom has been reported from the 1970's through into the 1980's. Rudnick and Krulik (1977) in presenting their 1975 study of the use of calculators in Grade 7 reported on the results of a survey returned by 450 parents (60% response rate). These parents were asked to express their opinions at the end of the survey. Most did, which according to the authors indicated the importance of the issue. Comments included:

- It's all right to introduce the calculator in higher grades, after the students learn their basic skills.
- Let's go back to teaching the basics, not teach our children to be dependent on a machine.
- Stop experimenting with our kids; you have already lost one generation to modern math.
- No way our kids should use the machines. Teach them basics.

(Rudnick and Krulik, 1979, p.230)
The arguments for and against the use of calculators in classes written about nearly 10 years ago are as current today. Dick (1988), commenting on an article from the editorial of the Wall Street Journal titled 'Classroom Calculators add to Math Illiteracy', reported that the article stated:

Calculators should not be permitted until the first or second year of high school mathematics, by which time the students will have completed their instruction in arithmetic. (Dick, 1988, p.37)

It was the opinion of this editorial that calculators should not be introduced in primary classes, continuing the argument as to the appropriate time for students to use calculators in mathematics classes.

Those who are against the use of calculators argue that they:

1. destroy all motivation for learning the basic facts,
2. discourage mathematical thinking,
3. cause a dependence on them for all calculations,
4. are inappropriate for slow learners,
5. block the opportunity to fully understand algorithmic processes, and
6. develop the notion that mathematics is nothing more than pressing buttons on a black box.

(Shultz, 1981, p.182)

Arguments For Calculator Use

Killingbeck (1981) has defended the use of calculators in the mathematics class suggesting that the issue is not mathematics but rather arithmetic.

I take issue with those who regard the pocket calculator as a 'bad thing'. People who take this view usually hold that children will somehow become lazy or not learn mathematics properly if they can rely on the calculator to do their sums for them. What the fuss is about, actually, is arithmetic, not mathematics. (p.10)

Howson and Wilson (1986) argued that the calculator's potential "for helping children come to terms with arithmetic has not been greatly exploited; neither has its use for the teaching of more sophisticated mathematical ideas and concepts" (p.66). Suydam (1987) supported the view
that "all students can profit from using calculators. When students with physical and mental handicaps use calculators, they score higher, are faster, and attempt more problems" (p.22). Yet there has still persisted the controversy and fear of calculators inhibiting children's mathematical knowledge. In discussing the fear that many have of calculators decreasing children's computational ability Willis and Kissane (1989) wrote that:

Perhaps because of the widespread fear that calculators may create unacceptable levels of dependence on the part of children, a great deal of research has been dedicated to finding the effect of use of calculators on mathematical achievement especially the acquisition of paper-and-pencil algorithms. The evidence consistently shows that calculators do not reduce computational facility. (p. 70)

Others (NCTM, 1986; Cockcroft, 1982; McIntosh, 1990) would have supported the report of the Review Panel of the Discipline Review of Teacher Education in Mathematics and Science (1989) which "urges the use of calculators in mathematics education to teach concepts, to eliminate wasteful repetitive pencil-and-paper activities, to encourage the exploration of numbers, to be used for checking and estimating, and for making the study of mathematics exciting, stimulating and non-threatening."(p. 69)

Along with such arguments for and against the use of calculators is the controversy of when and how they should be introduced into the teaching and learning of primary school mathematics, if at all. One teacher writing in the Arithmetic Teacher stated that "calculators as a teaching tool have a very definite place in my first grade" (Starkey, 1989, p.6). The teacher had invited parents and teachers into her classroom to work with and watch the children using calculators. She commented that the "parents are awed by their seven-year-old's logically solving problems that she or he might not have attempted without a calculator." (Starkey, 1989, p.7)
However, in a recent newsletter published in the United States of America for educational administrators, the controversy was still evident in the views expressed by a number of educators.

"Yes, recommending the appropriate use of calculators is wise."
Shirley Frye, President NCTM

"We may be guilty of ignoring basic mathematics, memory, and computational skills."
H. Dean Evans is Indiana state school superintendent

"Not only is increasing students' use of calculators wise, but failing to do so could be an educational disaster."
Dorothy Strong is mathematics director for the Chicago public schools

"Calculators should not be permitted until the first or second year of high school..."
John Saxon authors a mathematics textbook series
(Update, 1989, p.4-5)

It is of interest to read these comments in light of those made by Morris (1978) eleven years earlier that "the question is no longer whether calculators should be used in elementary school, but how they should be used." (p.24) Morris (1978) believed that the question of calculator use in the primary school had been answered. However, this is clearly not the case.

As early as 1980 the reluctance on the part of some teachers to use calculators was recognised as perhaps a factor in limiting the benefits of the calculator. Bitter (1980) wrote that it may also be the case that "teacher reluctance to allow their use in the classroom may negatively effect educational benefits desired from pocket calculator use" (p.323). Further evidence of the reluctance of some teachers to support the use of calculators was given by Blane (1986) when he wrote of a personal experience at a NCTM national conference. This divergence of opinion "was most clearly demonstrated to the author at the 1986 Conference of the National Council of Teachers of Mathematics (NCTM) in the USA where the 6000 or so delegates to this major mathematics education conference were picketed by
a group of teachers and others protesting against the official NCTM policy statement, 'Calculators in the Mathematics Classroom' (p.236). Perhaps the actions of those teachers indicated that they felt threatened for "in many ways teachers reflect the general community and part of themselves feel under attack when a de-emphasis on written computation (the old basics) is suggested" (Willis & Kissane, 1989, p.70).

For those who support the use of calculators, Yvon (1987) listed six benefits that he has found from teachers and students working with calculators in the mathematics classroom:

- A positive attitude towards mathematics.
- Increased self-confidence.
- Reinforcement of computational skills.
- More individualisation.
- Simplified checking.
- Peer co-operation and responsibility (p.16-17).


**Why use Calculators?**

**For students...**

- Calculators encourage inquisitiveness and creativity;
- Calculators have a motivating effect from an early age;
- Calculators increase confidence;
- Calculators reduce stress and time involved in computation;
- Calculators provide the opportunity to think about mathematical patterns/relationships without the burden of computation.

**For teachers...**

- Calculators support basic computational skills;
- Calculators cater for a broad range of achievement levels;
- Calculators are easily integrated with the mathematics and total school curriculum;
- Calculators allow children to work with large numbers;
- Calculators can be used to cope with real life problem solving-an ever increasing element of the mathematics programme;
• Calculators can develop and illustrate the importance of estimation skills;
• Calculators can provide immediate and positive feedback therefore misunderstandings can be rapidly diagnosed;
• Calculators can be used as an answer key;
• The calculator is an instructional aid for the development and reinforcement of mathematical concepts and processes;
• Current government policy highly recommends the use of calculators in all levels of schooling.

(Fenby et al, 1989, p.2)

This was a comprehensive list of benefits for the student use of calculators. The authors have recognised the availability and importance of calculators to primary mathematics classes.

Summary

Calculators have been available since 1965 (Moursund, 1981) and their use in mathematics classes from Kindergarten has been recommended by educational authorities in the United States of America, the United Kingdom and Australia. That calculators have not had the effect on the mathematics curriculum that was expected, has been due to the continuing controversy as to whether they should be used at all in schools.

There is support for the use of calculators because they can be used:

• to eliminate wasteful repetitive pencil-and-paper activities, to encourage the exploration of numbers, to be used for checking and estimating and for making the study of mathematics exciting, stimulating and non threatening.’
  (Discipline Review into Teacher Education in Mathematics and Science, 1989, p.69)

Further, research evidence consistently shows no detrimental effect on children's computational ability when calculators are used (Dessart and Hembree, 1986; Willis and Kissane, 1989).

Yet the issue of children's level of computational ability is a focus of community concern and the prime reason why many do not support the use of calculators in schools. People are worried that the use of calculators
may lead children to become too dependent on them and therefore not learn their basic facts and be unable to do pencil and paper algorithms.

In commenting on the arguments against the use of calculators Willis (1979) has written, "those who argue that students should not use calculators because they will become calculator dependent are not facing the reality of a world which has already become dependent on computing devices. The question is how and when we will use them, and for what purpose" (Willis, 1979, p.3). While considering these arguments there is a need to review the critical research concerning the student use of calculators in the classroom and the effect that their use must inevitably have on the content of the mathematics curriculum.
Section Two: Critical Research on the Student Use of Calculators

Willis and Kissane (1989) reported that there has been much research carried out into the effects on student achievement where calculators have been available. The research reviewed in this section focussed on three major areas:

a) The findings of major research on the effects of calculator use by students. A summary of the research carried out to the end of the 1980's indicated that there were "no negative effects in any study' where students used calculators" (Bell et al, 1983, p.309). Indeed a further study reported in 1986, which involved the meta-analysis of 79 research reports, concluded that "it no longer seems a question of whether calculators should be used along with basic skills instruction, but how" (Hembree & Dessart, 1986, p.97).

b) The Calculator - Aware Number (CAN) curriculum study, which involved children working with calculators in an open-ended approach to the teaching of mathematics. The findings of this study suggested that "children certainly show greater competence in mathematics at an earlier age than would normally be assumed. This is particularly true for large and small numbers, negative numbers, the ability to recognise patterns and awareness of their significance, and the understanding of place value. The growth in the children's development of concepts such as fractions, decimals square roots, has also become more evident during this second year of CAN development" (PrIME, 1989, p.12).

c) Research that focussed on attitudes towards the use of calculators found that in the early 1980's "very few believed that calculators should be used
instead of paper-and-pencil algorithms. Rather, it was felt their use should be postponed until after paper-and-pencil algorithms are learned" (NCTM, 1981, p. 17). By 1986 it was reported that for the primary years "students (were) seen to be strongly in favour of the use of calculators, whereas the parents were perceived to be strongly against. Teachers were again spread throughout the scale, but with a slightly larger proportion (44%) being strongly in favour" (Blane, 1986, p.237).

Research on the Effects of Calculator Use by Students

By the end of the 1970's most research on the effects of calculator use had been "performed with intermediate grade students" (Standifer & Maples, 1981, p.17). Suydam (1979, cited in Shumway et al, 1981) reported that "almost 100 studies on the effects of calculators have been conducted and most conclusions indicate no measurable detrimental effects associated with the use of calculators for teaching mathematics" (p.140).

Marilyn Suydam, through the Calculator Information Centre at the University of Ohio, published reviews of the research on calculator use in 1979 and 1980. These reviews assisted Bell et al (1983) in their research summary of the calculator issue for the Cockcroft Report. They reported that "'no negative effects appear in any study' where students used calculators" (p.309). However they did sound a word of warning regarding the place of calculators in mathematics classes:

   many reports indicate that mathematics teachers may be reluctant to use them. Moreover, the resistance is greater among teachers of younger children; primary teachers are most resistant to their use, while university teachers allow them with almost no concern (Bell et al, 1983, p.308).

This needs to be kept in mind, for Standifer and Maples (1981) have reported that most research on the student use of calculators had focussed
on intermediate grade students. Teachers in primary grades according to
Bell et al (1983) were reluctant to use calculators and as this was the case
there would be a limited number of studies available that focus on the
effects of student use of calculators in the primary years.

An analysis of the available research into the use of calculators in
mathematics classrooms up to the mid 1980's was carried out by Hembree
and Dessart (1986). Data gathered by Suydam up to that time indicated that
"less than 20% of the elementary teachers and less than 36% of the
secondary teachers in the United States of America have employed the
calculator in mathematics instruction" (Hembree & Dessart, 1986, p. 83).
Using this data as a base Hembree and Dessart decided to reassess the place
of calculators in the mathematics classroom. They undertook "to integrate
the findings of the research on effects on students of using calculators in
learning mathematics in Grades K-12" (Hembree & Dessart, 1986, p.84).
Seventy-nine studies which met the following criteria were selected for the
meta-analysis:

1. The study was concerned with students in the mainstream mathematics
   program in Grades K-12.
2. The study employed electronic hand-held calculators or desk calculators
   similar in appearance and function to hand-held devices.
3. The report included sufficient data for the calculation of effect size.
4. The report provided outcome data on a continuous scale.
5. Each sample contained at least 10 subjects, or at least 5 classes where
   classes were the units of analysis.  
   (Hembree & Dessart, 1986, p. 87)
Based on the findings of their meta-analysis Hembree and Dessart (1986) made the following recommendations for the use of calculators in mathematics classrooms:

1. Calculators should be used in all mathematics classes K-12.
2. Because of the apparent negative effects of calculators in Grade 4, calculator functions in that grade should be approached with caution.
3. Students in Grade 5 and above should be permitted to use calculators in all problem-solving activities, including testing situations. This recommendation is based on these two observations:
   a. Calculators greatly benefit student achievement in problem solving, especially for low- and high-ability students.
   b. Positive attitudes related to the use of calculators may help to relieve students' traditional dislike of word problems.

(Hembree & Dessart, 1986, p.97)

Comstock and Demana (1987) working with seventh and eighth graders on numerical problem solving using calculators supported this last finding. They found "that calculators keep students' interest levels high and inspire them to work numerous challenging problems not possible with only pencil and paper. In addition, teachers employing this approach have been able to get students to verbalize about mathematics because the calculator stimulates students' talk about mathematical situations" (p. 51). As a result of such findings and the recommendations from the meta-analysis study completed by Hembree and Dessart (1986) the NCTM reaffirmed their support for the use of the calculator by all students in all grades (1987).

Those who do not support the student use of calculators have commented on the year levels of Hembree and Dessart's (1986) study. Of the 79 studies analysed, 16 related to Grades K - 3, 41 to Grades 5 - 12 and 16 studies to Grade 4. Saxon (1987) argued that so few studies related to grades K-3 that insufficient research data had been produced to make any recommendations for these grades. This together with the negative effect found in Grade 4 led him to question the use of calculators in these grades. This view
highlighted the need for research to focus on the effects of the student use of calculators in the lower primary grades, Kindergarten to Year 4.

As early as the late 1970's work had been reported on the introduction of a calculator into the infant grades. A study reported by Foster (1979) involved two third-grade classes in Hobart, Australia, working with the Little Professor electronic calculator. This calculator "generates a sequence of over 16 000 basic problems in addition, subtraction, multiplication and division" (Foster, 1979, p.13). Foster (1979) reported that due to the small sample of only two classes that the results could not be generalized. However, he believed that:

There is little doubt that its introduction had a positive motivating effect; all children regardless of mathematical ability were extremely eager to use the calculators and a number arrived at school early each morning so as to gain 15-30 minutes practice (p.14).

A study carried out by Leechford and Rice (1982) which involved Grade 6 children also indicated a positive effect on students' achievement in computation and problem solving when they were given access to calculators.

Nevertheless as discussed in Section One of this review there existed within the community concern about the use of calculators in the teaching and learning of primary school mathematics. Saxon (1987) expressed doubt about the value of calculators in Grades K-4 and as often reported in the literature there existed a divergence of opinion among the community and teachers towards the use of the calculator (Shult, 1981; Blane, 1986; Dick, 1988; Perry, 1989). The time was right, as suggested by Reys and Reys (1987), "for longitudinal studies of students who have sustained school experience in a mathematics curriculum designed to take advantage of the power of the calculator" (p.14).
One such longitudinal study which focussed on the student use of calculators in the early primary grades was already under progress in the United Kingdom. Work on a Calculator-Aware Number (CAN) curriculum had begun in 1986.

Calculator-Aware Number (CAN) Curriculum

Project Description

In 1986 the Primary Initiatives in Mathematics Education (PrIME) Project began in the United Kingdom. A major element of this project was the research undertaken into the development of a Calculator-Aware Number (CAN) curriculum. This research, headed by Hilary Shuard, involved children having access to calculators from the age of six and seven.

The purpose of the CAN work was to observe the results of an open-ended approach to the teaching of mathematics using various problems and investigations with calculators available at all times for the children. The introduction of calculators was not on the basis of another tool in an existing scheme but rather as a focus on problem and investigation activities with calculators always available to the children and no emphasis given to the teaching of traditional pencil-and-paper computations.

The CAN work began in September 1986 with 800 six and seven year old children. It was the intention that these children would continue to work with CAN till age eleven. Each year as the CAN study continued there was another intake of six and seven year old children. The schools involved in CAN "represent a mixture of large and small schools in urban, country and suburban environments" (PrIME, 1989, p.4).
There was good support for all teachers involved in the project from the Local Education Authorities (LEAs) with advisors and advisory teachers attending classes and teacher meetings. Whenever possible, new teachers becoming involved in the CAN work were given the opportunity to visit CAN classes and to meet with other teachers and advisers who had been involved in the work.

The CAN philosophy as outlined in 'The Second Year of CAN' (1989) was based on the finding of Fitzgerald (1988) "that most adults now calculate either mentally, or when the numbers are too large or inconvenient use a calculator" (PrIME, 1989, p.6). The importance of mental calculation and the emergence of calculators in the workplace to work calculations gave cause to investigate the ways in which these methods of calculation could be introduced into the classroom.

Mental calculation is an essential part of the CAN philosophy. Children use pencil and paper, structural apparatus and practical approaches when appropriate. The CAN philosophy is not solely dependent on the calculator. It is taken for granted that children who are working on CAN always have a calculator available to use, whenever it is needed; however, it has become apparent that children do not always choose to use one. The emphasis of the number work in the CAN curriculum is on understanding of number and the ability to use number in a variety of situations, and in a variety of problem-solving and investigational activities. The standard vertical pencil-and-paper methods of calculation are not taught. (PrIME, 1989, p. 6-7)

**Findings**

It was found that as children developed their mental strategies for calculators they did not always use calculators. They preferred to use their own strategy. Here the children were revealing their independence of calculators, showing that they could calculate using both mental and calculator-based calculations. These, together with paper and pencil calculations, are acknowledged as the three methods available to people to work calculations. The children involved in CAN were given a lot of
autonomy as to how they went about solving problems. They were encouraged "to have more control over their learning" (PrIME, 1989, p.10). This seemed to foster positive attitudes among the children towards mathematics. It cannot be said that these positive attitudes towards mathematics were directly caused by the use of calculators or indeed the approach of CAN for there was no control group with which to compare the children's performances.

However, teachers were able to use their previous experiences with children of this age to report that:

The children certainly show greater competence in mathematics at an earlier age than would normally be assumed. This is particularly true for large and small numbers, negative numbers, the ability to recognise patterns and awareness of their significance, and the understanding of place value. The growth in the children's development of concepts such as fractions, decimals square roots, has also become more evident during this second year of CAN development. (PrIME, 1989, p.12)

The teachers, too, appeared to be given autonomy as they developed an open-ended approach to teaching, using the various problems and investigations that they themselves had devised for the children to do. Children had access to calculators to play with number and to explore various ways of solving problems. One outcome of the use of the calculator was that children were not limited with the numbers they could use and this resulted in children going much further with number than was 'traditionally' expected:

the CAN children have caused us to change our thinking about how children learn and their capacity for handling number. (PrIME, 1989, p. 9)

Teachers also found that "the use of calculators has encouraged CAN children to talk more about the mathematics they are doing. This increase
in mathematics talk in the classroom has strengthened the teacher's appreciation of the value of talk as a tool for learning mathematics" (PrIME, 1989, p.22). Del Campo (1986) reported a similar finding as a result of her work in Victoria involving Prep classes to Year 3 children using calculators.

Teachers involved in CAN found that they needed to be more flexible with their expectations of what children could understand and they needed to move away from the traditional teaching styles of mathematics. The CAN teachers were given support with each LEA having a co-ordinator to work alongside the teachers, to give advice, to help disseminate ideas and to arrange meetings "...for teachers to share ideas and activities, and to discuss common problems" (PrIME, 1989, p.29).

Not only was there an open-ended approach to the teaching of mathematics but there was also an open-ended invitation to parents and colleagues to come into the classrooms to observe what was happening to the children's mathematical learning. The report commented that "many parents have been very supportive of the development because they have recognised that their children now approach mathematics with greater confidence than before" (PrIME, 1989, p.31). There was an indication that "not all are as committed as this" (PrIME, 1989, p.32). No further comment was made as to why some were not.

General Findings

At this stage of the CAN study (1989) there were observed changes in:

- the mathematical learning of the children, with the development of mental strategies, higher levels of number work being attained than expected and the development of positive attitudes towards mathematics;
teaching styles, with teachers growing in confidence as they used the open-ended teaching approach.

Those involved with the CAN study were able to say that "CAN has changed the styles of teaching and learning, but it is not certain how far it is the calculator itself that has produced the changes" (PrIME, 1989, p.22). This study has shown the need for further longitudinal studies to be carried out on the student use of calculators in primary mathematics classrooms.

Attitudes Towards the Use of Calculators

This review of the critical research on attitudes towards the calculator considered research that has taken place in the workplace as well as schools, both secondary and primary.

In the workplace Fitzgerald (1988), in a study carried out in England, reported finding "positive attitudes... time and time again among employees of all ages towards the use of calculators" (p.8).

The primary reason put forward for this support was that the:

Effective use of a calculator can increase an employee's range of competence, overall rate of working and hence productivity. As with most tools, calculators enable people to do things which they could not otherwise do at all and to do more easily other things which they can already do by other methods. (Fitzgerald, 1988, p.8)

Earlier in the 1980's the NCTM had undertaken a survey known as the Priorities in School Mathematics Project (PRISM) (NCTM, 1981). This project sought the opinions of people involved at all levels of curriculum change as to the changes needed in mathematics education.
There were nine groups of people identified to complete the survey. These were:

AT subscribe to Arithmetic Teacher
MT subscribe to Mathematics Teacher
JC junior college mathematics teachers
MA college teachers of mathematics
SP supervisors of mathematics
TE mathematics teacher educators
PR principals of elementary and secondary schools
SB presidents of school boards
PT presidents of parent-teacher organizations


The first six groups were deemed "professional" while the last three were termed "lay". Over 10,000 surveys were posted out in 1978/79 with the return rate for each group ranging from 15% to 60%. One area surveyed was that of the respondents' opinion towards the use of calculators. The results showed that:

- Professional samples in general were much more supportive of increasing emphasis on calculators than were lay samples.
- The use of calculators to help children learn basic facts was given little support.
- Using calculators to learn why an algorithm works received, moderate support.
- Checking answers was a noncontroversial use of calculators ranking first among the possible uses of calculators.
- The use of calculators for solving word problems was strongly supported. However, the lay samples were not as supportive of the idea.
- Classroom availability of four-function calculators and programmable calculators was supported by more than 70% of all samples.
- Very few believed that calculators should be used instead of paper-and-pencil algorithms. Rather, it was felt their use should be postponed until after paper-and-pencil algorithms are learned.
- The use of calculators to allow slower students "to keep up with the rest of the class" was generally opposed.
- For finding the sum of several items, the use of calculators was strongly supported. But the use of calculators for subtraction was not favoured.
- The use of calculators for multiplication generally received minimal support unless the problems were perceived as easy. There was a similar lack of enthusiasm for using calculators for division.

(NCTM, 1981, p.16-18)
The findings from this project relating to the use of calculators in schools found:

- About two-thirds indicated that students should have calculators; however, many samples tended to be restrictive about the use to be made of these calculators.
- Support was very low for using calculators instead of pencil-and-paper algorithms.
- Little support was given for using calculators when learning basic number facts or taking a test.
- Strong support was given to using calculators for checking answers, doing a chain of calculations involving several different operations, and using trigonometry.

(NCTM, 1981, p. 30-31)

During 1985/86 the Mathematics Education Centre at Monash University carried out a survey "on the applications of calculators to mathematics teaching in Australia" (Blane, 1986, p. 235). The objectives of the project were:

- to provide information on the current situation of the availability of calculators in schools and the application of calculators to the teaching of mathematics in Australia.
- to describe existing priorities in content and emphasis in school mathematics programs needed for educating students to operate in an informatics-enhanced environment.
- to describe Australian practices, including the provision of exemplar materials for teaching selected topics in mathematics.
- to prepare guidelines on the application of calculators in mathematics teaching.

(Blane, 1986, p.235)

The survey covered years K-12 seeking opinions from teachers, parents and students. The findings indicated "a wide divergence both in practice and attitudes in this area of mathematics teaching with conflicting views on almost every aspect of what should be happening now and in the future" (Blane, 1986, p.235). Based on the results of the survey Blane (1986) reported "that the developments are neither as advanced as many people believe and assume, nor is there anything like total agreement, either within schools or in the wider community on how, or indeed whether, the integration of calculators can and should be achieved" (p.238).
When schools were asked to rate the opinions of their parents, teachers and students on the unrestricted use of calculators in their schools it was found that in the upper secondary levels "none of the groups: students, parents or teachers were thought to be 'strongly against' and 98% of students and 76% of teachers were 'strongly in favour', but only 33% of parents were so rated" (Blane, 1986, p.237).

For the lower secondary levels the results "showed that students were rated as being strongly in favour of the use of calculators, whereas their parents were thought to be strongly opposed. Teachers, however, seemed to be fairly evenly spread on this issue" (Blane, 1986, p.237).

For the primary years Blane (1986) found that "there was a similar pattern to that seen at the lower secondary level with students seen to be strongly in favour of the use of calculators, whereas the parents were perceived to be strongly against. Teachers were again spread throughout the scale, but with a slightly larger proportion (44%) being strongly in favour" (p.237).

In researching the attitudes of various groups towards the role of calculators in schools report findings have indicated an uncertainty among teachers and parents concerning their place in the primary mathematics class (NCTM, 1981; Blane, 1986). The report on the CAN curriculum (1989) indicated the ways in which children and teachers with open access to calculators were able to use them. The following section discusses the role of calculators in the mathematics classroom.
Section Three: The Perceived Role of Calculators in the Mathematics Classroom

The introduction of calculators to the mathematics class received support from the early 1980's with the release of the NCTM's Agenda for Action (1980) in America, the Cockcroft Report (1982) in the United Kingdom and the AMEP's Statement of Basic Mathematical Skills and Concepts (1982) in Australia. The national direction for the use of calculators in each country has been reviewed and it has been shown that the availability of calculators for all children is the recommended policy. As suggested by Del Campo (1986) "it no longer seems a question of whether calculators should be used along with basic skills instruction, but how" (p.240).

The Calculator-Aware Number (1989) curriculum project suggested ways in which calculators could be used in primary mathematics classes. Prior to this study many writers had commented on the perceived role of calculators in the mathematics class.

In preparation for the release of the NCTM's Agenda for Action (1980) a number of justifications for the use of calculators were identified:

The Instructional Affairs Committee of the National Council of Teachers of Mathematics (1976) identified several basic justifications for the use of hand-held calculators in mathematics classrooms. Among them were the following:

1. To encourage students to be inquisitive and creative as they experiment with mathematical ideas,
2. To reinforce the learning of basic number facts and properties,
3. To develop the understanding of computational algorithms,
4. To serve as a resource tool that promotes student independence in problem solving,
5. To be used to solve problems that previously have been too time consuming or impractical to be done with paper and pencil, and
6. To decrease the time needed to solve difficult computations. (Moursund, 1981, p.7)
Evidence was gathered on how calculators were currently being used by teachers in the mid seventies. Moursund (1981) reported:

The most frequently cited reasons for using calculators in schools, as stated by teachers, state supervisors of mathematics, mathematics educators in colleges and universities, and textbook publishers were summarized by Bell, Esty, Payne, and Suydam (1977) (p. 230-231) as follows:

1. They aid in computation. They are practical, convenient and efficient. They remove drudgery and save time on tedious calculation. They are less frustrating, especially for low achievers. They encourage speed and accuracy.

2. They facilitate understanding and concept development.

3. They lessen the need for memorization, especially when used to reinforce basic facts and concepts with immediate feedback. They encourage estimation, approximation, and verification.

4. They motivate. They encourage curiosity, positive attitudes, and independence.

5. They aid in exploring, understanding, and learning algorithmic processes.

6. They encourage discovery, exploration, and creativity.

7. They help in problem solving. Problems can be more realistic, and the scope of problem solving can be enlarged.

8. They exist. They are here to stay in the real world; so we cannot ignore them (p.7-8).

Koop (1977) wrote that calculators could be “used in a variety of ways in the classroom…for fun or games; for functional purposes; for pedagogical purposes” (p.6). In the classroom as a teaching tool Koop (1977) believed that "the calculator can be used in many ways for example to practise number facts, to teach place values, to introduce multiplication and division through repeated addition and subtraction and to investigate number patterns" (p.6).

Student access to calculators was an issue that Coburn (1987) believed teachers needed to address. He supported the view that "a calculator for each child is desirable, though circumstances may dictate one calculator for
every two students or some other ratio. It would be better to spread the
calculator use throughout the school year than to bunch the experiences in
one unit" (p.3).

Writing specifically for the primary mathematics class Lambert (1985)
identified four roles for calculators:

- as a learning aid to the understanding of mathematical concepts
- as a maths-motivator
- as a means of solving problems in a faster and more efficient way
- as a device which provides opportunity for trying to solve problems of a greater
  intricacy. (p. 1)

Comstock and Demana (1987) believed that "the hand-held calculator is a
powerful problem-solving tool. It can be used to develop concepts and
explore mathematical topics" (p. 48).

Williams too defended the place of calculators in the primary mathematics
class, believing that "experience has shown that the calculator...can be
cohesively integrated into the primary mathematics curriculum for Prep to
Year 6" (Williams, 1987, p.1). In supporting this statement he identified
three primary advantages of the calculator:

- it is intrinsically motivational
- it may be used to develop concepts
- it may be used to practise skills (Williams, 1987, p.1).

Further uses of calculators were identified by Reys (1989):

The calculator...

- allows the teacher to approach and develop topics in new ways.
- promotes the natural exploration of problem solving strategies and the
  application of intuitive processes.
- can quickly generate data to be studied. (p.169-172)
The calculator can save time since it allows time "many specimen
calculations of a given kind to be performed in the same time as it would
take to write out and perform one calculation on paper" (Killingbeck, 1981,
p.10). Reys (1989) added to this view, suggesting that "...using the calculator
as a computational tool provides teachers and students the time necessary to
focus student effort and concentration on conceptual understanding and
critical thinking" (p.168).

In a clear statement of the role of calculators in class, Howson and Wilson
(1986) wrote:

Calculators enable many children to use arithmetic for real situations, including
other school subjects, for they facilitate early work with large and small numbers.
Access to a calculator allows children to generate number patterns, to explore
number properties and to make and test hypothesis, whilst using them makes
children focus attention on the order of operations. They aid in the acquisition of
the important skills of estimating and approximating. Nevertheless there is still no
consensus on exactly how their capabilities can be best exploited in early
mathematics teaching. (p. 67)

This comment relating to the use of calculators in mathematics classes
supported an earlier view that they could be used for:

1. Checking computational work done with paper and pencil.

2. Games, which may or may not have much to do with furthering the mathematical
content, but do provide motivation.

3. Calculation: when numbers must be operated with, the calculator is used with
the regular textbook or program.

4. Exploratory activities, leading to the development of calculator-specific
activities where the calculator is used to teach mathematical ideas.
   (Shult, 1981, p. 18)

A further use was suggested by Killingbeck (1981):

playing about with numbers' has always been a way in which people have
developed an interest in mathematics, and modern pocket calculators give
unbounded scope for this. (p.11)
McIntosh (1990) wrote that "there are two essentially different purposes for which a calculator can and should be used in the classroom. The first, and most obvious, is as a number-cruncher to deal with computations that are awkward ... Planned activities with the calculator can help children with the acquisition and reinforcement of many mathematical concepts, skills and processes" (p. 33-34). He went on to comment that calculators were an additional learning aid in the classroom to be used to explore mathematical concepts. This supported the views of Shult (1981), Howson and Wilson (1986) and Reys (1989).

One important aspect of the student use of calculators is the role they may play in the development of mathematical language. Del Campo (1986) had reported that a major aim of her work with children from Prep classes to Year 3 was "to assist the children to develop accurate mathematical concepts and to acquire appropriate mathematical language" (p. 241). Through observations of the children involved in the study Del Campo (1986) concluded that "calculators are seen as an important vehicle for developing appropriate mathematical language and, therefore, an understanding of concepts and principles" (p. 241).

Yvon (1987) suggested the need for students to be shown when it was not appropriate to use calculators but to use mental calculations or when calculators were not available paper and pencil calculations would need to be made. McIntosh (1990) concurred that children need to be able to select the appropriate calculation method commenting on the role calculators have in complementing mental calculations. He listed within his conclusions:

3. Calculator usage should complement mental computation in the classroom to handle those calculations for which mental computation is inappropriate. (p. 37)
Williams (1987) insisted that "before each calculation is attempted, an estimate of the answer must be made to judge the reasonableness of what appears on the screen." (p. 2)

There has been much discussion about the perceived role of calculators in the primary mathematics class, with it being suggested by Comstock and Demana (1987) and Reys (1989) that calculators were mathematical tools to be used for a variety of purposes. A summary list of uses for calculators in the classroom is presented to indicate their potential role in the mathematics curriculum.

Perceived Uses of Calculators

calculators are seen as an important vehicle for developing appropriate mathematical language and, therefore, an understanding of concepts and principles.

(De Campo, 1986, p.241)

provides teachers and students the time necessary to focus student effort and concentration on conceptual understanding and critical thinking.

(Reys, 1989, p.168)

calculators enable many children to use arithmetic for real situations, including other school subjects, for they facilitate early work with large and small numbers.

(Howson and Wilson, 1986, p.57)

1. Checking computational work done with paper and pencil.
2. Games.
3. Calculation.
4. Exploratory activities.

(Shult, 1981, p.18)

to practise number facts, to teach place values, to introduce multiplication and division through repeated addition and subtraction and to investigate number patterns.

(Koop, 1977, p.6)
1. To encourage students to be inquisitive and creative as they experiment with mathematical ideas,
2. To reinforce the learning of basic number facts and properties,
3. To develop the understanding of computational algorithms,
4. To serve as a resource tool that promotes student independence in problem solving,
5. To be used to solve problems that previously have been too time consuming or impractical to be done with paper and pencil, an
6. To decrease the time needed to solve difficult computations.'
   (Moursund, 1981, p. 7)

   • as a learning aid to the understanding of mathematical concepts
   • as a maths-motivator
   • as a means of solving problems in a faster and more efficient way
   • as a device which provides opportunity for trying to solve problems of a greater intricacy.
   (Lambert, 1985, p. 1)

As calculators have become more readily available to schools and as support has been given to these perceived roles, educational authorities have recommended their use from the first years of primary school. The introduction of calculators into the primary mathematics classroom however, has implications for the content of the mathematics curriculum.
Section Four: Implications for the Curriculum

The Need for Curriculum Change

Calculators have become cheaper and more readily accessible for schools. Willis and Kissane (1989) stated that "calculators (even the most expensive) are of a price which mean that schools could contemplate the purchase of class sets, and are of a size that enable them to be easily carried between rooms and between school and home. Thus unlimited individual access and use by students is conceivable in the near term which is not the case with computers." (p. 58 )

Calculators have become relevant to the mathematics curriculum for "they are now the natural tools for which to carry out arithmetical operations. For that reason learning to use a calculator...must now become part of learning arithmetic" (Howson & Wilson, 1986, p. 66). They "have an essential role to play in the mathematics curriculum of the 1990's" (Howson & Wilson, 1986, p. 68). The need for curriculum change has emerged as schools gain access to calculators and teachers become supportive of the student use of calculators in all grades. Mathematics curricula need to reflect the content and pedagogical changes that the use of calculators have brought about.

McIntosh (1990) supported the place of calculators in the mathematics curriculum yet recognised the need to develop material for the majority of teachers to be able to implement calculators into their mathematics classrooms.

There is a great need for curriculum development in this area and for bringing together the experimental activities of individual teachers and projects into a coherent form which can provide an easily usable resource for the majority of teachers. (p. 35)
The CAN study (1989) also indicated a number of suggested changes to the content and teaching/learning styles of the primary mathematics class. The implications for the curriculum are significant. A review of suggested changes to the emphasis and content of the mathematics curriculum and to the methods of current assessment would support this view.

*Changes to Content*

For a child to be able to use calculators effectively and efficiently...

three basic computational skills seem essential when calculators are freely used:

- facility in single-digit arithmetic
- a good understanding of place value, including decimals
- ability to estimate and check.

(Bell et al, 1978, p. 31)

To these McIntosh (1990) added a fourth:

a clear understanding of the various operations and their purposes, and an ability to see in real-life situations what calculation is necessary, and to translate the calculator result back into its setting (p. 33).

In a strong comment Wiebe (1987) suggested that the availability of calculators has "nearly eliminated the need for pencil-and-paper computations at home and in the workplace" (p. 57). Yet, according to Wiebe (1987), the impact of calculators has not reached the classroom for "mathematics instruction in the elementary school classroom has changed little; the majority of class time is spent preparing children for the world of 1950, a time when calculators were expensive and cumbersome and the types of computations and numbers they could work with were extremely limited" (p. 57). Williams (1987) also believed that "an inordinate emphasis is placed on computation in elementary school mathematics, especially in the upper grades" (p. 21).
Clark and Kelly (1987) have presented the following list of ways in which calculators could be used in the primary mathematics curriculum.

1. To encourage inquisitiveness and creativity through experimentation.
2. The consolidation of facts and properties.
3. The understanding of algorithms.
4. As an 'answer key.'
5. To allow performance of realistic exercises with large numbers.
6. To develop estimation skills.
7. For problem solving.
8. Recognition of number patterns.
9. To decrease computation time.
10. The understanding of Consumer Maths. (p.103)

The authors deemed Consumer Maths to be that mathematics that children need to survive in their world.

These uses of calculators need to be reflected within the curriculum. For this to take place there needs to be an evaluation of what mathematics is to be taught and how it is to be taught with the increased availability of the calculator. According to Wiebe (1987) calculators will remain "the dominant method of doing arithmetic in the home and the workplace" (p.58). This being the case he has suggested changes that need to be made to the mathematics curriculum with the importance of mental calculation being emphasised.

**Mental Arithmetic**
Systematic instruction in mental arithmetic should be a standard part of the elementary school mathematics curriculum, receiving as much emphasis as pencil-and-paper computation.

**Numeration**
The meaning of numerals for whole numbers should receive much greater emphasis

**Decimals and Fractions**
Decimal numeration should be taught starting in the second or the third grade as an extension of whole-number numeration and activities with fractions.

**Pencil-and-Paper computation**
Instructional time with pencil-and-paper computation should be limited to computations with two- or three-digit numbers and to meaningful and easy-to-remember algorithms.
Order of operations and parentheses
Instruction should start with the standard hierarchy of operations and with the use of parentheses for changing that sequence.

Integers
The third or fourth grade might be the appropriate time to develop the meaning of negative numbers.

Problem Solving
...when children are learning to use problem-solving strategies they should use calculators where appropriate and examine their results to see if they are reasonable.

Instruction in calculator use
Students should be taught all the functions of typical inexpensive calculators... Calculators should be as much a part of the elementary school mathematics classroom as the textbook and manipulative materials. (Wiebe, 1987, p. 58-60)

The importance of mental arithmetic within these changes cannot be overstated. Wiebe wrote that "since the calculator is the dominant method of computing answers to arithmetical problems, the need for mental arithmetic has increased greatly." (Wiebe, 1987, p.57).

However, the findings of Fitzgerald (1988) suggested that a worry among teachers was "that dependence on calculators will result in a diminution in mental arithmetic and numerous employees admitted to me that they felt that this had been so for them. I suspect that, to some extent, this is inevitable"(p. 10). He went on to argue that "if appropriate mental skills are to be developed then alternative ways of doing this will need to be found. Rather than tedious rote learning, game situations might be more effective, including activities of 'beat the calculator' kind" (Fitzgerald, 1988, p. 10).

The appropriate use of calculators, pen and paper algorithms and mental strategies to complete calculations needs to be emphasised. Yvon (1987) suggested the need for students to be shown when it was not appropriate to use calculators but to use mental calculations or when calculators were not available to use paper and pencil calculations.
Commenting on the use of calculators Williams (1987) highlighted that "before each calculation is attempted, an estimate of the answer must be made to judge the reasonableness of what appears on the screen" (p. 2). If there was an emphasis on estimation before the calculator was used, the child would be able to compare the answer to check whether or not it was reasonable. Coburn (1989) supported the view that the "child should also be taught to evaluate whether the computed answer is reasonable. This process requires more thinking than that which is needed for the rote manipulation of a paper-and-pencil algorithm" (p. 45). Children also need to know which operation to use and they need to be able to identify the right buttons to push and the correct order to push them.

It is just as important to know when to multiply, for example, as to know how to multiply.....a calculator is no help if you don't know what buttons to push. (McCrae, 1979, p. 25)

With the introduction of calculators into schools Sullivan (1986) has stated that "while some parents and teachers express the concern that 'calculators will make them lazy', exactly the reverse is the case. Calculators mean that teachers and pupils alike will have to think more" (p. 251).

In evaluating what was currently available to assist the teacher McIntosh (1990) believed that the material available does not truly integrate calculators into the mathematics curriculum. He reported that:

Productive work is now being done in looking seriously at the implications of living in a calculator age and in producing more central calculator-based material for primary schools. However, it is still true that almost all the published material for calculators provides isolated activities often trivial or peripheral, which may provide material for a 'calculator lesson' but do not help integrate the calculator as a normal feature of the primary mathematics classroom. (p. 39)
The mathematics curriculum needs to have more emphasis placed on developing student's estimation skills, their mental strategies and their ability to assess the reasonableness of answers. Students also need to be able to select the appropriate method of calculation (calculator, pen and paper or mental strategy) for the computation. In concentrating on the need for possible content changes we need to keep in mind the pedagogical changes suggested by the CAN (1989) study and most importantly, the development of appropriate assessment procedures.

**Changes to Assessment**

It has yet to become accepted that "if calculators are to be used in all grades and students are to have calculators on their desks during classwork, then the tests used by these students to evaluate their achievement in mathematics must assume that calculators are present" (Williams, 1987, p.23).

If calculators were to be used for computational work Williams (1987) argued that the following curriculum changes need to occur:

1. Students in all grades have unrestricted use of calculators.
2. A calculator-integrated curriculum for grades 1-8 must be developed.
3. Once a calculator-integrated curriculum is in place, calculators can be used in all testing situations, perhaps with one exception. (p. 22)

This exception being the testing of student's knowledge of basic facts. The testing of this aspect of a child's mathematical knowledge would need to be done without a calculator available.

It is accepted that children use calculators outside the classroom and that their use in the mathematics classes is likely to increase. During the 1980's the United States of America, the United Kingdom and Australia have all
formulated policies and curriculum documents which recommended the use of calculators from the earliest grades. Yet Willis and Kissane (1989) have argued that the tests that these authorities use and support do not reflect such stated policies.

Curriculum documents which, in their preface, argue convincingly for a de-emphasis on standard written computation, still place written computation at the heart of the curriculum and mental arithmetic as a 'value added' extra rather than providing the fundamental restructuring of number work which is needed. Systems which prepare progressive policy statements on calculator use, and on related changes in the mathematics curriculum, produce multiple choice tests of achievement which almost totally neglect the 'new' in favour of the 'old' - because the new isn't easily assessed by methods developed to serve different purposes. (p.75)

The call for changes to curriculum content and assessment will be difficult to implement. Coburn (1989) has commented that:

Curriculum reform with limits on paper-and-pencil computation because the electronic calculator is making much written computation obsolete. Reform will not come smoothly, however. The public will be skeptical...Those having vested interests in current standardized testing, current textbooks, and the traditional curriculum will also be resistant to change. (p. 43)

A Difficult Task

Statements from the NCTM (1989), the Cockcroft Report (1982) and National Statement on the Use of Calculators for Mathematics in Australian Schools (1987) all recommend that calculators become an essential part of the mathematics class. For this to occur curriculum developers and teachers need to support several curriculum changes. Reys (1987) has suggested that they need to:

1. Become knowledgeable about the research on calculators. In the past ten years over 200 research studies have focussed on effects of calculators,... The results have been remarkably consistent in showing that "calculator use does not appear to affect achievement adversely." (Driscoll 1981; Hembree and Dessart 1986)

2. Recognize the intangible benefits of calculator use.
3. Develop an "open" calculator policy. Every school should have a clear calculator policy that is understood by every student, parent, and teacher. Interviews with teachers have revealed that calculator policies either do not exist, are not known, or are not understood.

4. Allow students to explore with calculators.

5. Never require students to use calculators to check paper-and-pencil computations. Checking paper-and-pencil work doesn't reflect the real-world use of a calculator. No one does paper-and-pencil computation and then uses a calculator.

6. Administer standardized achievement tests in mathematics that have portions designed for calculator use.

7. Update mathematics curriculum guides. (p. 12-14)

McIntosh (1990) has projected that "the experimental activities of individual teachers and projects" need to be brought together "into a coherent form which can provide an easily usable resource for the majority of teachers" (p. 35).

As early as 1983 it was possible to list the way in which calculators would enter the mathematics class. Bell et al (1983) suggested a three-phase introduction of the calculator into mathematics classes:

   a) the introduction of calculators with no planned modification of patterns of teaching and learning;

   b) use of the calculator as a teaching aid as well as a computing aid with appropriately designed teaching procedures and materials, but with no modification of current curriculum procedures;

   c) modification of the curriculum in the light of universal use of calculators. (p.308)

This has been the process by which calculators have entered the primary mathematics classroom. The end of the 1980's has seen the recommendation for using calculators from the early years of primary school. Evidence in Australia (Discipline Review, 1989) has indicated that calculators have not been accepted into the classroom curriculum. Thought and planning needs to be given by curriculum designers as to the most
effective way to implement the changes to the mathematics curriculum that have come about as a result of the student use of calculators.

**Contemplating Curriculum Change**

In contemplating any curriculum change thought needs to be given to how effective change can be generated. It is far more than the release of a policy statement or a syllabus. Questions leading to effective implementation need to be considered. These questions include:

- What needs to be known about the teachers' readiness?
- What networks need to be organised to facilitate the curriculum change?
- What resources need to be made available to support the change?

Burkhardt, Fraser and Ridgway (1989) in their paper *The Dynamics of Curriculum Change* focussed their attention on some of these questions.

In introducing the issue of curriculum change they stated that "a brief overview of historical evidence revealed that there was no established effective method of planned curriculum change" (p. 403). The authors then asserted "that planned curriculum change is very difficult to achieve on a large scale" (Burkhardt et al, 1989, p.404). They wrote that many curriculum innovations, programs and proposals are written and implemented into systems. However when the classrooms are examined there may be evidence of low 'take up'.

Burkhardt et al (1989) believed that a curriculum change that showed evidence of low 'take up' concerned the emphasis in the early 1960's of "the usefulness and power of mathematics in practical situations and the need to
foster appropriate process skills in students. In the outcome, this aspect was barely visible in the classrooms in which the resultant materials were used, where 'practical situations' were entered, if at all, as another sort of mathematical content" (p.404). Low 'take up' was seen by the authors as an issue that needed to be given attention when contemplating curriculum implementation.

In endeavouring to change a system there were some central issues at a teacher level that Burkhardt et al (1989) identified.

**Teacher variables**
Teacher knowledge, style, performance level, adaptability and support requirements require study, both in general and in the context of each development, with typical teachers in realistic circumstances.

**Professionalism**
It implies that what one qualified teacher can do, any qualified teacher can do. It is an assumption that is neither plausible nor borne out by evidence.

**Inertia**
Innovators should keep the question "Why should anyone change?" high on the planning agenda of their work. In order to be widely adopted, we suggest that a change should:
1. Make life easier for the teacher;
2. Make life more fun for the teacher;
3. Address a problem that is already identified as such;
4. Have some measure of public support.

(p. 410-411)

At an organisational level Davis and Salasin (1975, cited in Burkhardt et al, 1989) have developed a list of issues that need to be considered:

**Ability** — refers to the organization's ability to devote resources to the proposed innovation.

**Values** — refers to the attitudes of all the groups to the proposed innovation. Unless the goals underlying the innovation are shared by the people who are to implement it, success is unlikely. Detailed information about attitudes to specific aspects of the proposed innovation is far more useful than global impressions.

**Information** — refers to the credibility of the proposed innovation as well as to the information which people require in order to implement it. Training is a major problem. Integration of new aspects of curriculum into the old framework requires expertise and teacher time.

**Circumstances** — innovations are more likely to be successful when applied to organizations where the roles of the participants are well defined and where good interpersonal relationships exist.

**Timing** — the occurrence of other events at the same time the innovation is proposed is likely to have a negative effect on the success of the innovation.
**Obligation** — key people within the organization must feel the need to change current practices so that they are in accordance with the proposed innovation.

**Resistance** — there are many aspects of resistance. The weakest level is simple passive resistance; more dramatic is strongly articulated direct opposition.

**Yield** — people need some motivation for embarking on innovative activities. (p. 412 - 413)

In deciding which curriculum approach could be taken in implementing change Burkhardt et al (1989) discussed the Big-bang revolutionary model versus the gradual evolutionary model. Each has its advantages and disadvantages. The Big-bang approach was described as being very direct, setting out the specific changes but has the disadvantage that it is assumed that a committee or group of people "knows what will work for typical teachers and students in realistic circumstances" (Burkhardt et al, 1989, p. 415). The gradual model takes time but by only concentrating on smaller aspects of the curriculum the "approach can build up substantial change over a few years" (Burkhardt et al, 1989, p. 415). They identified the disadvantage of this approach as lacking "the glamour and the evangelical attributes that may be important in attracting public and professional support for change and propelling it forward" (Burkhardt et al, 1989, p. 415).

Associated with an innovation are effective agents of change. These are listed by Burkhardt et al (1989) as assessment, teacher development and classroom materials, assessment being one way to support change in that you assess for the innovation.

If the examinations are based, as they often are, on a narrow spectrum of mathematical activity that emphasises exercises of technical skill, the classroom will reflect that emphasis. (Burkhardt et al, 1989, p.417)

Teacher development as an agent of change is recognized to be of central importance....It is clear that substantial changes in the classroom behaviour of most teachers are essential for many of the new curriculum activities generally regarded as important. (Burkhardt et al, 1989, p.418)
The writers believed that "while classroom materials are ineffective on their own, they are essential as support for most teachers' change" (Burkhardt et al, 1989, p. 418). The role of the textbook is very much underestimated and in order to support curriculum change "more extensive collaboration between publishers and curriculum developers is required urgently" (Burkhardt et al, 1989, p. 418).

The Place of Inservice

One of the supports recommended by Burkhardt et al (1989) was the role of professional development. At the beginning of the 1980's with a growth in the use of calculators in the mathematics class Baker (1982) suggested that there was "an established need for in-service work" (p.163). An investigation by Bitter (1980) had suggested that some of the controversy amongst teachers and the community regarding the use of calculators could be overcome through actual 'hands on' calculator workshops.

In investigating this issue Bitter (1980) administered an attitudinal survey to a group of elementary school teachers before and after a two-hour calculator workshop. Bitter (1980) found that there was "a significant gain in attitude" (p. 324) towards the use of the calculators. Even though the study was limited to 84 teachers, there was the indication that teacher development through some form of inservice may develop more favourable attitudes toward the use of hand-held calculators in primary mathematics classes.

Of note in the Cockcroft Report (1982) was the definite statement "that priority should be given...to providing associated in-service training for teachers" (para 388) on the use of calculators in the primary school. Blane and Willis (1986) in their report of the UNESCO/CDC survey found that
"29% of the sample considered that there was 'no need' for in-service in this topic. For the majority, who did want some form of in-service, the most frequently suggested format was for school-based workshops lasting either half or a whole day" (Blane & Willis, 1986, p. 24).

With the increase in knowledge of the teaching of mathematics and the inclusion of calculators in the mathematics curriculum from Kindergarten to Year 12 the call for inservice development continued through the 1980's. Coburn (1989) considered that "teachers need staff development programs that help them develop a broader, more global view of computation" (p. 54).

Willis and Kissane (1989) strongly supported the role of inservice workshops.

The opportunity for teachers to participate in extended workshops which help them understand the potential and problems of calculators is probably the most efficient means to bring about change in the use of calculators.

Firstly, teachers are likely to realise that the use of calculators does not reduce the need for mathematics but instead demands different often more sophisticated skills. Secondly, they may be reassured that use of calculators will not undermine their students' learning and may broaden their own teaching. Thirdly, it should increase teachers' sense of personal comfort and control over changes in their practice. (p.85 )

This view was supported by the NSW Teachers' Federation where comment was made that "adequate inservice to classroom teachers during the implementation stage was demanded by teachers. This inservice should be provided during school hours" (Sharkey, 1990, p. 11). Teachers supported the need for in-service courses in the implementation phase of curriculum change, though they believed that these inservice courses should be held during school hours.
Developing a Policy

In Lindsay's article 'Calculators in Perspective' (1977) the discussion on the use of calculators in mathematics classrooms focussed, primarily, on its effect in secondary schools and its place in public exams. At this time there was no stated policy on the use of calculators and Lindsay argued strongly that "the lack of any coherent policy on methods of calculation in secondary schools is educationally unhealthy, and it makes it difficult for teachers to give their pupils the positive leadership to which they are accustomed" (p. 7). One report, in the late 1970's, on school policies toward the student use of calculators suggested that "many schools forbid the use of calculators as an aid to calculation until their students have mastered the 'basic facts'" (Willis, 1979, p. 3).

By the end of 1989 curriculum statements in the United States of America, the United Kingdom and Australia had recommended the student use of the calculator from Kindergarten. The extent to which these national statements have been supported by teachers, implemented into the mathematics class and incorporated into a school policy statement need to be investigated.

Summary

The electronic hand-held calculator has been available since 1965 (Moursund, 1981). During this time its great promise to many has been "that it enables a student to concentrate on the problem at hand, without it being obscured with what, to some students, seems to be an impenetrable barrier of calculation" (Willis, 1979, p. 3).

Yet over the last 25 years there has continued to be a controversy within the community concerning the use of calculators in the mathematics classroom.
Although inexpensive calculators have been available and have been used in schools for several years their place in mathematics education remains limited and controversial. (Willis, 1979, p.3)

During the 1970’s and 1980’s there had been a gradual international move towards the recommended student use of calculators from Kindergarten. The 1970’s had seen research focus on the effect of the calculator on students’ computational skills. This research and the ensuing discussion led to the publication of the NCTM’s Agenda for Action (1980) including Recommendation 3 on the use of calculators in the mathematics class.

This was followed in England with the release of the Cockcroft Report (1982) which further discussed the place of calculators in the mathematics classroom. The findings of Hembree and Dessart’s meta-analysis in 1986 led the NCTM (1987) to reaffirm its policy on the student use of calculators. The release in the United States of America of the Curriculum and Evaluation Standards for School Mathematics (1989) recommending calculators be made available to all students in all grades set the focus for the student use of calculators for the 1990’s. In Australia, Blane and Willis (1986) had recommended that a National Statement on the use of calculators in classrooms be developed. This national policy statement was released in 1987 with all state educational authorities supporting the view that calculators be available to students from Kindergarten.

There have been clear directions given by research (Hembree & Dessart, 1986), reports (NCTM, 1980; Cockcroft, 1982), national statements (CDC & AAMT, 1987) and state education systems (NSW Department of School Education, 1989) as to the place of calculators in mathematics classes. During 1989-1990 there has been the development of a National Statement
of Principles of Mathematics in Australian Schools which supported the use of calculators from K-12. Of most importance 1990 has seen the report of work carried out in the United Kingdom on the Calculator-Aware Number curriculum. Yet Perry (1989) has commented that "there is still a deal of antagonism from these settings with feelings that the introduction of such technology will lead to a generation of innumerate children" (p.162).

Presently there exists an increasing curriculum policy direction for the student use of calculators by all students in all classes, while at the same time there continues to be a community controversy and an apparent divergence of opinion amongst teachers over their use. Thus it is important to gauge teachers' current attitudes towards the student use of calculators in primary mathematics classes.
Chapter 3

METHODOLOGY

This chapter reports on the development of the questionnaire used to gather data for this study. It is organised under the following headings:

- Review of Issues
- Description of the Population
- Pilot Study and Resultant Changes
- Questionnaire
- Administration of the Questionnaire
- Method of Analysis

Review of Issues

The major issues that emerged from the literature review were related to:

- the ways in which calculators are used;
- the grade from which calculators should be used;
- the continuing community controversy over the use of calculators;
- the support teachers required for the effective introduction of the calculator into primary mathematics classes.

These and other issues formed the basis of the research questions within the study.

Over the last 20 years calculators have become readily available to the community and their use in schools has been shown to be increasing (Moursund, 1981; ICME, 1984; FASTS, 1988). It was evident from the review of the literature and the discussion of current curriculum policies in the United States of America, the United Kingdom and Australia that the use of calculators in mathematics classes was now recommended from Kindergarten to Grade 12 (NCTM, 1989; AEC, 1990; CAN, 1989).
Within Australia there has been little research carried out on teachers' attitudes towards the use of calculators in the primary mathematics class. The study by Blane and Willis (1986) had found teachers evenly spread in their attitudes towards their use in the upper primary years, with some supporting their use and others opposed. There had been several approaches suggested as to how the use of calculators could be implemented in the primary mathematics class. The AEC (1990) suggested that there be specific calculator lessons focussing on the skills to be taught for the correct use of calculators. The NCTM (1989) recommended that calculators be available to students on a routine basis and that students be given free access to them as needed. Acknowledgement was made that calculators were mathematical tools (Howson & Wilson, 1986) and educational authorities have recommended that they be introduced into the mathematics curriculum from Kindergarten. (NCTM, 1989; AEC, 1990).

Their role in the classroom was perceived to be varied. The literature review suggested that calculators could be used for games (Koop, 1977), in problem solving (Lambert, 1985), for computation work (Reys, 1989), number exploration (Wilson, 1986), estimating and checking (Discipline Review Report, 1989) and in developing mathematical language (Del Campo, 1986). There was also the acceptance that they were part of our everyday world (Koop, 1979) and a part of the technological change that is taking place in our society. There was consistent research evidence that the use of calculators did not reduce computational skill. Indeed they may even have a positive effect on the performance of students (Bell et al, 1983; Hembree & Dessart, 1986; Willis & Kissane, 1989). In fact research findings indicated that the introduction of calculators into the mathematics class has a positive effect on children's motivation and enthusiasm in doing
mathematics (Foster, 1979; ICME, 1984; Comstock & Demana, 1987; Suydam, 1987). The work of the PrIME project and specifically the CAN curriculum work (1989), which focussed on the early primary years, found that when calculators were used the children's knowledge of number was beyond that expected from them at that age.

Though there appeared to be a variety of uses for calculators amongst teachers the predominant use was that of calculating devices (Blane & Willis, 1986). In their report these authors suggested that perhaps teachers were unaware of how to implement the use of calculators in other ways. Such findings supported the role of professional development courses for teachers in implementing calculators into the primary mathematics classroom (Willis & Kissane, 1989).

Throughout the literature it was apparent that staff development/inservice courses needed to be made available for the possibility of effective curriculum change to take place (Bitter, 1980; Cockcroft, 1982; Baker, 1982; Coburn, 1989; Burkhardt et al, 1989). It was suggested that such staff development courses be in the form of school-based workshops (Blane & Willis, 1986).

At the same time as research findings have shown no reduction in students' computational skill when calculators were used, there continued to be community controversy as to the place and role of calculators in the mathematics curriculum. Research findings have suggested a divergence of opinion existed amongst teachers and amongst parents as to the use of calculators in mathematics classes (Bitter, 1980; Shultz, 1981; Cooper & English, 1985; Del Campo, 1986; Perry, 1989; McIntosh, 1990).
These findings then formed the basis for asking teachers:

- how their students currently used calculators,
- how calculators could be used,
- from what year calculators should be introduced,
- their willingness to be involved in professional development courses,
- their perception of parents' attitudes towards the student use of calculators in primary mathematics classes.
Description of the Population

Population
The target population for this study comprised all the primary teachers in all the primary schools in New South Wales.

Sample Group
From this stated population the sample of teachers chosen were those undertaking a course of study towards their fourth year qualification, Bachelor of Education (Primary). It was assumed that this sample would contain currently practising primary teachers and that their attitudes would be representative of teachers as a whole. A limitation of the study was that all teachers in the sample share the characteristic of undertaking their fourth year of study and thus the findings cannot be generalised to the population of all the primary teachers in New South Wales. It could also be assumed that this sample population may differ from the remaining teachers in the state in that they may have a heightened awareness of curriculum policies and advanced knowledge of calculator usage through the course work that they were completing.

The available sample became those teachers attending particular lectures on given nights at:

- University of Western Sydney, Nepean;
- University of Western Sydney, Macarthur;
- Australian Catholic University Sydney, Strathfield.
Pilot Study and Resultant Changes

Pilot study of the Questionnaire
A draft of the questionnaire (Appendix A) was piloted in 1989 at University of Western Sydney, Westmead using a group of 25 teachers completing the fourth year of their Bachelor of Education (Primary). As a result of the pilot study several difficulties with particular questions in the questionnaire and its overall construction were identified and changes were made.

Resultant Changes to the Questionnaire

Cover Letter
Due to the time lapse (August 1989 to May/August 1990) between the pilot study and administration of the final questionnaire changes needed to be made to the cover letter.

The cover letter for the pilot study (Appendix A) indicated to the teachers that with the imminent release of the NSW Department of School Education K-6 Mathematics Syllabus, the issue of the student use of calculators in primary mathematics classes was being discussed in the community. Their responses to this questionnaire would give educational authorities direction as to teachers' attitudes towards this issue.

The NSW K-6 Mathematics Syllabus was released in October 1989. As the full study was completed in May/August 1990 this timing necessitated a change in tense within the structure of the cover letter.
Questionnaire

The following changes were made to the structure of the questionnaire as a result of the pilot study:

1. There were no new questions developed, however, a renumbering of the three parts to Questions 6, 7 and 8 resulted in the change from a 14-item to a 20-item questionnaire.

<table>
<thead>
<tr>
<th>Pilot Study</th>
<th>Full Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>remained</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
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<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>became</td>
</tr>
<tr>
<td>7</td>
<td></td>
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<tr>
<td>8</td>
<td></td>
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<td>9</td>
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<td>10</td>
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<td>11</td>
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<td>12</td>
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<td>13</td>
<td></td>
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<td>14</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6,7,8</td>
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<tr>
<td>2</td>
<td>9,10,11</td>
</tr>
<tr>
<td>3</td>
<td>12,13,14</td>
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<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
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<td></td>
<td>17</td>
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<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

2. The initial direction of "Circle the appropriate response" on page 1 of the questionnaire was changed to "Circle the appropriate numerical response".

3. The "Yes"/"No" response requested on page 2 that had caused much confusion in the pilot study needed careful consideration in the final format. Page 2 of the questionnaire contained Questions 7 through to 11. Of these Questions 7, 8, 10 and 11 required "Yes"/"No" responses.
For each of these, the responses were introduced with the beginning of a statement:

Question 7  Students use calculators:
Question 8  Students do not use calculators because:
Question 10 I am supportive of the use of calculators because:
Question 11 I do not support the use of calculators because:

Changes made to specific questions are outlined below:

<table>
<thead>
<tr>
<th>Question</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Change made to the years of teaching experience.</td>
</tr>
<tr>
<td></td>
<td><strong>from</strong> 0-5 years  5-10 years  10-15 years  more than 15 years  <strong>to</strong> 0-5 years  6-10 years  11-15 years  more than 15 years</td>
</tr>
<tr>
<td>3</td>
<td>Change to introduction and response a).</td>
</tr>
<tr>
<td></td>
<td><strong>from</strong> Are you a: a) classroom teacher  <strong>to</strong> Are you currently a: a) permanent classroom teacher</td>
</tr>
<tr>
<td>4</td>
<td>Change to response h).</td>
</tr>
<tr>
<td></td>
<td><strong>from</strong> h) Other class, please specify type and grouping e.g. composite Yr 5/6  <strong>to</strong> h) Other class,</td>
</tr>
<tr>
<td>6</td>
<td>Inclusion of a third response choice and directions given for each response.</td>
</tr>
<tr>
<td></td>
<td><strong>from</strong> Do you presently have students using calculators in your mathematics classes? a) Yes b) No  <strong>to</strong> Do you presently have students using calculators in your mathematics classes? a) Yes (If yes, go to question 7) b) No (If no, go to question 8) c) Currently not teaching mathematics (If so, go to question 9)</td>
</tr>
<tr>
<td>9</td>
<td>Directions given for each response.</td>
</tr>
</tbody>
</table>
Methodology: Pilot Study and Resultant Changes

from Are you supportive of the student use of calculators in primary mathematics classes?
   a) Yes
   b) No

to Are you supportive of the student use of calculators in primary (K-6) mathematics classes?
   a) Yes (If yes, go to question 10)
   b) No (If no, go to question 11)

10 Change in the wording of response e)

from I am not too sure of how they can be used

to Unsure

12 Directions given for each response.

from Does your school have a policy on the student use of calculators in primary (K-6) mathematics classes?
   a) Yes
   b) No
   c) Unsure

to Does your school have a policy on the student use of calculators in primary (K-6) mathematics classes?
   a) Yes (If yes, go to question 13)
   b) No (If no, go to question 14)
   c) Unsure (If unsure, go to question 15)

15 Change in term used in the question to be consistent with the responses.

from class to Year

16 Change in response choice e).

from I am not too sure of how they can be used

to Unsure

17 Change in the response choice d).

from inservice courses.

to professional development courses.

18 Change in the term used within the question from inservice to school professional development courses.
Methodology: Pilot Study and Resultant Changes

From: Have you attended any inservice courses on the use of the calculator in primary (K-6) mathematics classes?

To: Have you attended any school based professional development courses on the use of the calculator in primary (K-6) mathematics classes?

20

Inclusion of a third response choice of 'Unsure' and the word 'parents' was highlighted.

From: In your opinion, do parents generally support the student use of calculators in primary (K-6) mathematics classes?
   a) Yes
   b) No

To: In your opinion, do parents generally support the student use of calculators in primary (K-6) mathematics classes?
   a) Yes
   b) No
   c) Unsure

As well as the stated changes to the cover letter, those to the structure of the questionnaire and those to particular questions, some typographical errors in the pilot study questionnaire were corrected.
The Questionnaire

The final format of the questionnaire (Appendix B) comprised 20 items administered to an available sample of primary teachers to gather data on their attitudes toward the student use of calculators in primary (Kindergarten to Year 6) mathematics classes.

These teachers were all in New South Wales undergoing their fourth year of study part-time towards their Bachelor of Education (Primary) at two campuses of the University of Western Sydney (Nepean and Macarthur) and one campus of the Australian Catholic University, Sydney (Strathfield).

Structure of the Questionnaire

The 20 questions were categorised into two sections:

Section 1 contained Questions 1 to 5 and identified the respondent's:

- Question 1: sex,
- Question 2: years of teaching experience,
- Question 3: position within school,
- Question 4: year presently teaching, and
- Question 5: range of classes taught.

Section 2 comprised the rest of the questionnaire directed at issues involving the student use of calculators in primary mathematics classes.

- Question 6: Do students presently use calculators?
- Question 7: How do children use calculators in the classroom?
- Question 8: Why aren't children using calculators?
- Question 9: Do teachers support the student use of calculators?
- Question 10: Why do teachers support the student use of calculators?
- Question 11: Why don't teachers support the student use of calculators?
- Question 12: Does the teacher's school have a calculator policy?
- Question 13: What is the focus of the school policy?
Question 14: Why isn’t there a school policy on the student use of calculators?

Question 15: From what year should the calculator be used by students in primary mathematics classes?

Question 16: How can the calculator be used by students in primary mathematics classes?

Question 17: What are the influences that have formed your attitude towards the student use of calculators?

Question 18: Have you attended any school based professional development courses on the use of calculators in primary (K-6) mathematics classes?

Question 19: What times would teachers be prepared to attend school based professional development courses?

Question 20: What are teachers’ perceptions of the parent support for student use of calculators in primary mathematics classes?

Open Comment

At the end of the questionnaire teachers were given the opportunity to write any other comments that they wished to make about the student use of calculators in primary mathematics classes. The purpose of this comment was to allow teachers an opportunity to express themselves more fully on any issue related to the student use of calculators.

Responding to the Questionnaire

In responding to the questionnaire teachers were asked to circle the appropriate numerical response/s for each question. Questions 1, 2, 3, 4, 5, 6, 9, 12, 13, 15, 18, 19, and 20 required teachers to give a single response while more than one response was possible for questions 7, 8, 10, 11, 14, 16, and 17.

Those who completed the questionnaire did not have to respond to each question. There were two paths through the questionnaire depending upon the choices made in Questions 6, 9 and 12. All teachers who responded to the questionnaire completed Questions 1 through 6, Question 9, Question 12, and Questions 15 through 20. Responses to Questions 7, 8, 10, 11, 13 and 14 were dependent upon the teachers' responses to Questions 6, 9 and 12.
Identifying Questionnaire Pathways

Teachers were asked if they had students presently using calculators in primary mathematics classes (Question 6), if they were supportive of the student use of calculators in primary mathematics classes (Question 9), and if the schools in which they were teaching had developed a policy on the student use of calculators in primary mathematics classes (Question 12).

Depending upon their responses to these questions teachers were given directions to the next question to answer:

- **Question 6**: teachers were given directions to go to either Question 7, 8 or 9;
- **Question 9**: teachers were given directions to go to either Question 10 or 11;
- **Question 12**: teachers were given directions to go to either Question 13, 14 or 15.

The final construction of these three questions was presented as:

6. Do you presently have students using calculators in your mathematics classes? 
   a) Yes (If yes, go to question 7)  
   b) No (If no, go to question 8)  
   c) Currently not teaching mathematics (If so, go to question 9)  

9. Are you supportive of the student use of calculators in primary (K-6) mathematics classes? 
   a) Yes (If yes, go to question 10)  
   b) No (If no, go to question 11)  

12. Does your school have a policy on the student use of calculators in primary (K-6) mathematics classes? 
   a) Yes (If yes, go to question 13)  
   b) No (If no, go to question 14)  
   c) Unsure

In providing the varying pathways through the questionnaire reasons why responses were made were investigated.
Instrument

The instrument used for gathering the data for this research was a 20-item questionnaire with an attached cover letter (Appendix B). This cover letter:

- explained to the teachers the issue of the questionnaire;
- identified the source of the questionnaire; and
- indicated that the information gathered would give education authorities direction as to teachers' attitudes towards the student use of calculators in primary mathematics classes.
Administration of the Questionnaire

Access to the teachers at each campus was through the relevant Post-Graduate Studies Co-ordinator. Initially, the Co-ordinator was contacted through a telephone call for permission to administer the questionnaire. Once approval was given a suitable date for administration of the questionnaire to students was chosen. The questionnaire was administered at each campus between May/August, 1990.

Instructions

In administering the questionnaire teachers were asked to read the cover letter where the purpose of the study was outlined. The instructions given were to read and complete the questionnaire.
Method of Analysis

The collected data were analysed using frequency responses calculated with the use of the Statistical Package for the Social Sciences (Revised edition) as trialled with the pilot study. There were 61 variables in total comprising the possible answers to the 20 questions. Each variable was given an identifying number and label (Appendix C). To assure ease of identification of individual questionnaires they were numbered from 1 through till the end according to the colour coding.

The campuses were identified as:

   Nepean............. blue........... 1
   Macarthur......... yellow........ 2
   Strathfield........ green.......... 3

Analysis of Data

The collected data were analysed for response rates for each variable from each campus and then the overall response rate for each variable from all completed questionnaires. There were three procedures used in the analysis of the data:

1. A frequency count of responses for each variable from each campus was calculated.
2. A cumulative frequency count of responses to each variable from all collected data was calculated.
3. All open comments were collated and classified according to descriptive characteristics.

This study carried out during 1990 sought teachers' attitudes towards the student use of calculators in primary mathematics classes. The structured questionnaire was administered to fourth year students at three Sydney university campuses.
It is acknowledged that a limitation to the study is that the findings though representative of a group of teachers cannot be generalised to all teachers. The completed questionnaires were collected and analysed, the report of which is presented in the following chapter.
Chapter 4

DATA ANALYSIS

For the purposes of this study teachers completing their fourth year of study part-time towards their Bachelor of Education (Primary) were asked for their responses to a questionnaire investigating primary teachers' attitudes toward the student use of calculators in primary (Kindergarten to Year 6) mathematics classes.

This study investigated the following research questions:

1. Do teachers presently have students using calculators in primary mathematics classes?
2. How are students currently using calculators in primary mathematics classes?
3. Why don't teachers have their students using calculators?
4. Do teachers support the student use of calculators in primary mathematics classes?
5. Why do teachers support the student use of calculators?
6. Why don't teachers support the student use of calculators in primary mathematics classes?
7. Do schools have a policy for the student use of calculators?
8. What is the focus of school policies on the student use of calculators?
9. Why don't schools have a policy on the student use of calculators?
10. From what class do teachers believe student use of calculators should begin?
11. How do teachers believe calculators can be used by students?
12. What influences have helped form teachers' attitudes towards student use of calculators in primary mathematics classes?
13. Are teachers willing to attend school based professional development courses to learn how to use calculators in the primary mathematics classroom?
14. When are teachers willing to attend professional development courses?
15. What are teachers' perceptions of the parent support for student use of calculators in primary mathematics classes?
The questionnaire was administered to three Sydney tertiary campuses in 1990 with 127 completed questionnaires being collected:

- University of Western Sydney, Nepean ......................... 54
- University of Western Sydney, Macarthur ....................... 23
- Australian Catholic University Sydney, Strathfield ............ 50

The data collected were analysed using descriptive statistics in the following ways:

1. A frequency count of responses for each item from each campus was analysed to suggest possible findings of significance.

2. A cumulative frequency of responses to each item from all collected data was analysed to suggest possible findings of significance.

3. All open comments were collated and classified according to the major focus of the comment.

The collected data were analysed using the Statistical Package for Social Sciences Revised Edition (SPSSX) program. The analysis of data is reported in the following sections with the campuses being referred to as Nepean, Macarthur and Strathfield.
The questionnaire was administered to three Sydney tertiary campuses in 1990 with 127 completed questionnaires being collected:

University of Western Sydney, Nepean ........................................ 54
University of Western Sydney, Macarthur ................................... 23
Australian Catholic University Sydney, Strathfield .................... 50

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3. All open comments were collated and classified according to the major focus of the comment.

The collected data were analysed using the Statistical Package for Social Sciences Revised Edition (SPSSX) program. The analysis of data is reported in the following sections with the campuses being referred to as Nepean, Macarthur and Strathfield.
Analysis of Each Question by Frequency Counts

The analysis begins with a report on the demographic data collected from questionnaire items 1 to 5 for each campus and the overall sample.

The frequency response rate for each research question is reported under the campus headings of Nepean, Macarthur and Strathfield. These data were combined to present the total number of responses for each questionnaire item.

Frequency of response rates was presented in percentage tables where relevant. There were no percentage tables given for items in questions 7, 8, 10, 11, 13 and 14 for not all respondents answered each of these questions. Responses to these items were based on the respondent's answer to Questions 6, 9 and 12. It would not be appropriate to give percentage tables as the percentage would not be out of the total number of respondents in the study and could lead to confusion.

After the discussion for each question general findings were listed. These findings were identified by a number e.g. 18.1, read as the first reported finding from question 18. There was no priority of importance attached to the numbering of each finding. They were presented in this manner for ease of referencing.

The data for item 20, open comments (Appendix D), were analysed by inspection and grouped according to the major focus of each comment.

Demographic Information: Questions 1 to 5

Set out in Table 4.1 is the demographic information gathered from each of the campuses for the first five questions as well as the total percentage count.
and frequency response rate for all completed questionnaires. Any discrepancies in percentage totals were due to missing responses on the completed questionnaires.

<table>
<thead>
<tr>
<th>Question</th>
<th>N</th>
<th>M</th>
<th>S</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>1. Sex:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) male</td>
<td>20.4</td>
<td>26.1</td>
<td>16</td>
<td>19.7</td>
</tr>
<tr>
<td>b) female</td>
<td>79.6</td>
<td>73.9</td>
<td>84</td>
<td>80.3</td>
</tr>
<tr>
<td>2. Length of teaching:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 0 - 5 years</td>
<td>79.6</td>
<td>87.0</td>
<td>68</td>
<td>76.4</td>
</tr>
<tr>
<td>b) 6 - 10 years</td>
<td>11.1</td>
<td>-</td>
<td>12</td>
<td>9.4</td>
</tr>
<tr>
<td>c) 11 - 15 years</td>
<td>5.6</td>
<td>-</td>
<td>6</td>
<td>4.7</td>
</tr>
<tr>
<td>d) more than 15 years</td>
<td>3.7</td>
<td>13.0</td>
<td>14</td>
<td>9.4</td>
</tr>
<tr>
<td>3. Currently a:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) permanent classroom teacher</td>
<td>61.1</td>
<td>65.2</td>
<td>78</td>
<td>68.5</td>
</tr>
<tr>
<td>b) casual teacher</td>
<td>25.9</td>
<td>17.4</td>
<td>12</td>
<td>18.9</td>
</tr>
<tr>
<td>c) teaching executive</td>
<td>3.7</td>
<td>4.3</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>d) non-teaching executive</td>
<td>-</td>
<td>4.3</td>
<td>-</td>
<td>0.8</td>
</tr>
<tr>
<td>e) other</td>
<td>7.4</td>
<td>8.6</td>
<td>6</td>
<td>5.5</td>
</tr>
<tr>
<td>4. Class currently teaching is:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Kindergarten</td>
<td>13.0</td>
<td>8.7</td>
<td>14</td>
<td>12.6</td>
</tr>
<tr>
<td>b) Year 1</td>
<td>14.8</td>
<td>4.3</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>c) Year 2</td>
<td>11.1</td>
<td>8.7</td>
<td>16</td>
<td>12.6</td>
</tr>
<tr>
<td>d) Year 3</td>
<td>5.6</td>
<td>4.3</td>
<td>14</td>
<td>8.7</td>
</tr>
<tr>
<td>e) Year 4</td>
<td>11.1</td>
<td>21.7</td>
<td>10</td>
<td>12.6</td>
</tr>
<tr>
<td>f) Year 5</td>
<td>7.4</td>
<td>4.3</td>
<td>14</td>
<td>9.4</td>
</tr>
<tr>
<td>g) Year 6</td>
<td>5.6</td>
<td>8.7</td>
<td>8</td>
<td>7.1</td>
</tr>
<tr>
<td>h) Other class</td>
<td>16.7</td>
<td>21.7</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>5. Range of classes usually taught:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) K - 2</td>
<td>29.6</td>
<td>-</td>
<td>28</td>
<td>23.6</td>
</tr>
<tr>
<td>b) 3 - 6</td>
<td>16.7</td>
<td>34.8</td>
<td>34</td>
<td>26.8</td>
</tr>
<tr>
<td>c) K - 6</td>
<td>51.9</td>
<td>52.2</td>
<td>36</td>
<td>45.7</td>
</tr>
</tbody>
</table>

These data showed that of those who responded to the questionnaire 80% were female and 20% male. Of the 127 teachers involved in the study 76% were in their first five years of teaching. The percentage of female/male teachers appeared representative of the current primary teaching service in NSW and it could be assumed that most teachers completing their Bachelor of Education (Primary) would be in their first few years of teaching. Of those
who responded to the survey 68.5% were permanent classroom teachers while 18.9% were casual teachers. There was little response to the categories of "teaching executive" and "non-teaching executive".

The teachers were spread across the primary years with 23% identifying themselves as usually teaching Years K-2 and 27% teaching Years 3-6. These teachers were in their early years of teaching and they may see themselves in terms of K-2 (Infants) or 3-6 (Primary) teachers rather than K-6 teachers because they only identify themselves with those classes so far taught.

Research Issues: Questions 6 to 20
There were fifteen research questions within this study (Questions 6 to 20 of the questionnaire) concerning issues related to teacher attitudes towards the student use of calculators in primary mathematics classes. These research questions were grouped under the issues of:

- Current Use
- Teacher Support for Calculators
- Calculator Policies
- Year of Introduction
- Calculator Uses
- Influences
- Professional Development Courses
- Parent Support

The analysis of the data collected for each question was presented in table form showing the frequency response for each campus and the total response count.
Data Analysis: Analysis of Each Question by Frequency Counts

Percentages of teacher responses were only given for questions where all respondents were able to answer. For all other questions the frequency rate of response was given. This was done in order not to confuse the statistical results. Percentages refer to the total possible number of responses (127) from the sample. Frequency response rates identify a group of teachers responses from the total sample.

Analysis of the collected data, discussion and relevant findings for each research question follow.

Current Use

<table>
<thead>
<tr>
<th>Response</th>
<th>Nepean</th>
<th>Macarthur</th>
<th>Strathfield</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25.9</td>
<td>34.8</td>
<td>38</td>
<td>32.3</td>
</tr>
<tr>
<td>No</td>
<td>66.7</td>
<td>47.8</td>
<td>56</td>
<td>59.1</td>
</tr>
<tr>
<td>Currently not teaching mathematics</td>
<td>7.4</td>
<td>17.4</td>
<td>4</td>
<td>7.9</td>
</tr>
</tbody>
</table>

*Table 4.2: Present use of calculators by students (Question 6)*

It was found that within the sample of teachers surveyed there were 32.3% who had their students using calculators in primary mathematics classes and 59.1% who did not. There were almost twice as many teachers whose students were not using calculators as those who were.

Comparison of the data collected from the three campuses showed fewer teachers from Nepean (25.9%) responded that they had students using calculators than either Macarthur (34.8%) or Strathfield (38%).

Findings:

6.1 Fifty-nine per cent of teachers did not have their students using calculators.

6.2 Thirty-two per cent of teachers had their students using calculators.
Table 4.3: Current uses of calculators (Question 7)

<table>
<thead>
<tr>
<th></th>
<th>Nepean N=14</th>
<th>Macarthur N=8</th>
<th>Stfield N=19</th>
<th>Total N=41</th>
</tr>
</thead>
<tbody>
<tr>
<td>as the need arises</td>
<td>8</td>
<td>7</td>
<td>14</td>
<td>29</td>
</tr>
<tr>
<td>for specific lessons on calculator activities</td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>as a tool for problem solving</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>for computation work</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>to reinforce estimation skills</td>
<td>11</td>
<td>6</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>as a reward</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>other</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

The responses for this question were taken only from those teachers who presently had their students using calculators as indicated in Question 6.

These teachers responded that they used calculators as the need arose as much as having specific lessons on calculator activities. There was strong support for using calculators to reinforce estimation skills and as a tool for problem solving. There was less support for their use in computation and there were ten responses that indicated calculators were used as a reward. Some teachers specified that their students used calculators to check answers and in lessons that focussed on children discovering how calculators work.

Findings:

7.1 Of the 41 teachers who indicated that they had students using calculators, ten used it as a reward.

7.2 Calculators were used primarily as the need arose and for specific lessons on calculator activities.

7.3 Teachers indicated that calculators were used more to reinforce estimation skills and as a tool for problem solving than for computation work.
### Table 4.4: Reasons for teachers not having their students using calculators (Question 8)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Nepean N=36</th>
<th>Macarthur N=11</th>
<th>S'field N=28</th>
<th>Total N=75</th>
</tr>
</thead>
<tbody>
<tr>
<td>they are too expensive</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>they are not relevant for my class</td>
<td>12</td>
<td>4</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td>they are too difficult to organise</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>I am concerned about parent reaction</td>
<td>2</td>
<td>9</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>there are no calculators available</td>
<td>12</td>
<td>5</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>there is no school policy on their use</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>I am unaware of teaching/learning activities</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>other</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

The findings for this question were of great interest for they indicated why teachers did not have their students using calculators. Teachers were able to give more than one response for this question which allowed them to state all reasons that they considered important.

The major reasons reported for students not using calculators were that "there are no calculators available" and that "there is no school policy on their use". Twenty-six teachers responded that they did not see calculators as being relevant for their class while fourteen teachers indicated that they were "unaware of teaching/learning activities". When identified twelve of these teachers were Kindergarten teachers. In the total study there were sixteen teachers who said that they were currently teaching Kindergarten. Of these, twelve said that calculators were not relevant for their students.

There were more teachers at Nepean who responded that they were unaware of teaching/learning activities than at the other two campuses. Teachers had indicated that this was a reason why they did not have students using calculators. When tested for significance the measured chi square with four degrees of freedom was 19.07. The expected chi square at the 0.05 level of significance was 9.49. It may be that mathematics courses for teachers undergoing pre-service and inservice study at Nepean need to
Data Analysis: Analysis of Each Question by Frequency Counts

have included in their content more teaching/learning activities related to the use of calculators. There were three teachers who indicated that they did not use calculators because "they are too difficult to organise".

Fourteen teachers responded that their students were not using calculators because they were unaware of teaching/learning activities that could be used. This raised the issue of school based professional development courses and the need for schools to identify this as one way to develop teachers’ knowledge on the student use of calculators. It also suggested the possibility of some classroom research by teachers into the ways in which calculators could be used in the classroom.

Eleven teachers reported that their students were not using calculators because they were too expensive to purchase. Concern over parent reaction was identified by eleven teachers as a reason for not having students use calculators.

Teachers at Macarthur were more concerned about parent reaction than either Nepean or Strathfield. When this difference was tested for significance the measured chi square with four degrees of freedom was 14.16. The expected chi square at the 0.05 level of significance was 9.49. This significant difference indicated that teachers at Macarthur were more concerned about parent reaction than the other two campuses and this could be investigated further.

Findings:

8.1 The main reasons for not using calculators were the lack of availability and the absence of school policies.

8.2 Twenty-six teachers responded that calculators were not relevant for their class.
8.3 Eleven teachers believed that calculators were too expensive.

8.4 Fourteen teachers responded that they were unaware of teaching/learning activities.

8.5 Eleven teachers were concerned over parent reaction while three teachers did not have their students using calculators because of the organisation needed.

Teacher Support for Calculators

**Table 4.5: Teacher support for student use of calculators (Question 9)**

<table>
<thead>
<tr>
<th>Response</th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>85.2</td>
<td>87.0</td>
<td>84.0</td>
<td>85.0</td>
</tr>
<tr>
<td>No</td>
<td>13.0</td>
<td>8.7</td>
<td>16.0</td>
<td>13.4</td>
</tr>
</tbody>
</table>

The support of 85% of teachers for the student use of calculators in primary mathematics classes suggested that there was the acceptance of the place of calculators in the primary mathematics curriculum. As part of Blane's (1986) study schools were asked to rate teacher opinions as to the unrestricted student use of calculators. It was reported that for the primary years "teachers were again spread throughout the scale, but with a slightly larger proportion (44%) being strongly in favour" (Blane, 1986, p.237). The present study did not seek to measure degrees of support but there was an indication of increased teacher support for the student use of calculators in primary mathematics classes. There were 13.4% of teachers who did not support the student use of calculators in the primary years.
Findings:

9.1 Eighty five per cent of teachers supported of the student use of calculators in primary mathematics classes.

9.2 Thirteen per cent of teachers did not support the student use of calculators in primary school mathematics classes.

Table 4.6: Teacher reasons for supporting student use of calculators (Question 10)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Nepean N=46</th>
<th>Macarthur N=20</th>
<th>Stfield N=42</th>
<th>Total N=108</th>
</tr>
</thead>
<tbody>
<tr>
<td>they speed up children's work</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>they are a technological tool for use in mathematics</td>
<td>39</td>
<td>18</td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td>89</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>they help to reduce individual differences children</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>use them outside the classroom</td>
<td>30</td>
<td>13</td>
<td>20</td>
<td>63</td>
</tr>
<tr>
<td>they can help develop problem solving skills children</td>
<td>31</td>
<td>15</td>
<td>30</td>
<td>76</td>
</tr>
<tr>
<td>gain confidence through using them</td>
<td>33</td>
<td>16</td>
<td>25</td>
<td>74</td>
</tr>
<tr>
<td>they take the focus off computation in doing problems</td>
<td>20</td>
<td>12</td>
<td>12</td>
<td>43</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel they increase children's motivation</td>
<td>33</td>
<td>18</td>
<td>23</td>
<td>74</td>
</tr>
<tr>
<td>other</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

The respondents to this question were those teachers who indicated support for the student use of calculators in their response to Question 9. Eighty-nine teachers supported the use of calculators because "they are a technological tool for use in mathematics". There was also strong support from teachers for their use because "they can help to develop problem solving skills" (76 responses), "they increase children's motivation" (74 responses) and "children gain confidence through using them" (74 responses). Teachers further supported the use of calculators because "children use them outside the classroom" (63 responses).

There was less teacher support for the use of calculators because "they speed up children's work" and "can help to reduce individual differences" than for all other reasons. It was of interest to note that one teacher at Strathfield...
campus supported the use of calculators because they "can help to reduce individual differences" compared to eight responses at Nepean and seven at Macarthur.

Findings:

10.1 The main reason identified by 89 teachers for supporting student use of calculators was that they are a technological tool for use in mathematics.

10.2 Seventy-four teachers indicated that they supported the student use of calculators because they increase children's confidence. There were also 74 teachers who supported their use because children gain confidence through using them.

10.3 There were 43 teachers who supported the student use of calculators because they take the focus off computation in doing problems.

10.4 That children use calculators outside the classroom was identified by 63 teachers as a reason that they supported the student use of calculators in primary mathematics classes.

10.5 The least rated reasons for supporting the student use of calculators were they speed up children's work and they help to reduce individual differences.

Table 4.7: Teacher reasons for not supporting student use of calculators (Question 11)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Nepean</th>
<th>Macarthur</th>
<th>St'field</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=8</td>
<td>N=3</td>
<td>N=8</td>
<td></td>
<td>N=19</td>
</tr>
<tr>
<td>they reduce the need for children to learn basic facts</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>they discourage mathematical thinking</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>calculators should only be used in high schools</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>children won't learn pencil and paper computational skills</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>they are too expensive</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>other</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The highest response rates given by teachers for not supporting the student use of calculators were "they reduce the need for children to learn basic facts" and "children won't learn pencil and paper computational skills".
There was a belief amongst ten teachers that calculators "discourage mathematical thinking" and nine teachers believed that they "should only be used in high schools". This last reason has implications for the introduction of calculators into primary mathematics classes for if teachers feel strongly that calculators should only be used in high schools it will be difficult for them to implement their use in the primary classes as recommended by state and national policies.

Findings:

11.1 There were nine teachers who indicated that they did not support student use of calculators because they believed calculators should only be used in high schools.

11.2 Fifteen teachers did not support the student use of calculators because they reduce the need for children to learn basic facts.

11.3 There were thirteen teachers who did not support the student use of calculators because they believed children won't learn pencil and paper computational skills and ten teachers because they believed calculators discourage mathematical thinking.

Calculator Policies

Table 4.8: Frequency of school calculator policy statements (Question 12)

<table>
<thead>
<tr>
<th>Response</th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>18.5</td>
<td>13</td>
<td>28</td>
<td>21.3</td>
</tr>
<tr>
<td>No</td>
<td>40.7</td>
<td>47.8</td>
<td>50</td>
<td>45.7</td>
</tr>
<tr>
<td>Unsure</td>
<td>38.9</td>
<td>39.1</td>
<td>20</td>
<td>31.5</td>
</tr>
</tbody>
</table>

A minority of teachers (21.3%) were sure that their school had a calculator policy. There were 45.7% teachers who responded "No" and 31.5% of teachers were "Unsure" whether their school had a policy on the student use of calculators.
There were more teachers at Strathfield (28%) who responded that their school had a calculator policy than Macarthur (13%) and Nepean (18.5%).

Findings:

12.1 Twenty-one per cent of teachers indicated that their school had a policy on the student use of calculators.

12.2 Thirty-one per cent of teachers indicated that they were "Unsure" if their school had a policy on the student use of calculators.

12.3 There were 46% of teachers who responded that their school did not have a policy on the student use of calculators.

<table>
<thead>
<tr>
<th>Table 4.9: Focus of school calculator policy (Question 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepean N=9</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>students K-6 are allowed to use them</td>
</tr>
<tr>
<td>students 4-6 are allowed to use them</td>
</tr>
<tr>
<td>students are not allowed to use them</td>
</tr>
<tr>
<td>other</td>
</tr>
</tbody>
</table>

Of those teachers who responded that their school had a calculator policy the focus of these policies was investigated in this question. Of the 29 who were aware of their school's policy on student use of calculators, sixteen responded that in their policy "students K-6 are allowed to use them". There were ten teachers who indicated that their school's policy was that "students 4-6 are allowed to use them". It was of interest to note that nine of these ten responses came from teachers at Strathfield. When tested for significance the measured chi square with six degrees of freedom was 13.86; the expected chi square at the 0.05 level of significance was 12.59.
Findings:

13.1 Schools which had a policy on the student use of calculators varied in their focus.

13.2 There were sixteen teachers who indicated that their school had a calculator policy that allowed all students K-6 to use them and ten who responded that only those students in Years 4-6 were allowed to use calculators.

<table>
<thead>
<tr>
<th></th>
<th>Nepean</th>
<th>Macarthur</th>
<th>S'field</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>not seen as a priority</td>
<td>11</td>
<td>4</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>unaware of official policy</td>
<td>10</td>
<td>4</td>
<td>15</td>
<td>29</td>
</tr>
<tr>
<td>need parental opinion</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>waiting for directions for their use in schools</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>other</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

Teachers responded that there was not a school policy because they were "unaware of official policy" and that it was "not seen as a priority". There were twelve teachers who responded that they were "waiting for directions for their use in schools" and five who indicated that they "need parental opinion". When asked to specify other reasons seven teachers said that they had "no idea" why their school did not have a calculator policy.

Findings:

14.1 Twelve teachers indicated that they were still waiting for directions on the student use of calculators before a school policy was developed.

14.2 Twenty-three teachers responded that there was not a school policy on the student use of calculators because it was not seen as a priority.

14.3 Twenty-nine teachers indicated that their school did not have a school policy on the student use of calculators because they were unaware of official policy.
Year of Introduction

<table>
<thead>
<tr>
<th></th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Stfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>22.2</td>
<td>39.1</td>
<td>42</td>
<td>33.1</td>
</tr>
<tr>
<td>Year 1</td>
<td>16.7</td>
<td>4.3</td>
<td>6</td>
<td>10.2</td>
</tr>
<tr>
<td>Year 2</td>
<td>14.8</td>
<td>21.7</td>
<td>6</td>
<td>12.6</td>
</tr>
<tr>
<td>Year 3</td>
<td>16.7</td>
<td>13.0</td>
<td>16</td>
<td>15.7</td>
</tr>
<tr>
<td>Year 4</td>
<td>3.7</td>
<td>4.3</td>
<td>6</td>
<td>4.7</td>
</tr>
<tr>
<td>Year 5</td>
<td>9.3</td>
<td>13.0</td>
<td>16</td>
<td>12.6</td>
</tr>
<tr>
<td>Year 6</td>
<td>3.7</td>
<td>4.3</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>not at all in primary classes</td>
<td>5.6</td>
<td>4.0</td>
<td>-</td>
<td>3.9</td>
</tr>
</tbody>
</table>

There were 33.1% of teachers supportive of the introduction of calculators in Kindergarten while 55.9% of teachers responded that the student use of calculators should begin by the end of Year 2. This did not support the state and national policies that have recommended the student use of calculators from Kindergarten. However it did indicate that the majority of teachers supported their introduction by the end of Year 2. There was support for the use of calculators in the primary years and the vast majority of teachers (89.9%) supported their use by the end of Year 5. There continued to be a small number of teachers who believed that calculators should not be used at all in primary classes.

Comparison of campus responses to the year in which student use of calculators should begin showed fewer teachers at Nepean (22.2%) supported their introduction in Kindergarten than Macarthur (39.1%) or Strathfield (42%). There was stronger support from the teachers at Nepean for its introduction in Year 1. More teachers at Macarthur (65.1%) supported the introduction of the calculator by the end of Year 2 than either Nepean (53.7%) or Strathfield (54%).
Findings:

15.1 Forty-two teachers supported the introduction of the calculator in Kindergarten.

15.2 There were 71 teachers who believed that the calculator should be introduced by the end of Year 2.

15.3 There were five teachers who believed that calculators should not be introduced in the primary classes.

Calculator Uses

<table>
<thead>
<tr>
<th>Uses</th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>in problem solving activities</td>
<td>77.8</td>
<td>78.3</td>
<td>80</td>
<td>78.7</td>
</tr>
<tr>
<td>in doing algorithms</td>
<td>44.4</td>
<td>65.2</td>
<td>52</td>
<td>51.2</td>
</tr>
<tr>
<td>in exploration activities</td>
<td>79.6</td>
<td>82.6</td>
<td>82</td>
<td>81.1</td>
</tr>
<tr>
<td>for number pattern work</td>
<td>63.0</td>
<td>65.2</td>
<td>64</td>
<td>63.8</td>
</tr>
<tr>
<td>unsure</td>
<td>5.6</td>
<td>8.7</td>
<td>2</td>
<td>4.7</td>
</tr>
<tr>
<td>I don't think they should be used</td>
<td>3.7</td>
<td>4.3</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>other</td>
<td>-</td>
<td>13.0</td>
<td>6</td>
<td>6.3</td>
</tr>
</tbody>
</table>

There was a strong indication that calculators should be used "in exploration activities" and "in problem solving activities". There was a belief that they could be used "for number pattern work" and although they could be used "in doing algorithms" there was not the same degree of support as for those uses previously mentioned.

There was a difference in the response rates amongst the campuses for the use of calculators "in doing algorithms". Fewer teachers at Nepean (44.4%) supported this use than at Macarthur (65.2%) or Strathfield (52%). When this difference was measured for significance the chi square with four degrees of freedom was 9.88; the expected chi square at the 0.05 level of
significance was 9.49. This may indicate that at all campuses the role of calculators in doing algorithms needs to be considered when the content of mathematics courses is being developed and taught.

There were six teachers who were "Unsure" how calculators could be used by students in primary mathematics classes and five teachers who thought that they should not be used at all. Teachers also specified that calculators could be used for self marking, checking work and in games to reinforce known skills.

Findings:

16.1 Eighty-one per cent of teachers indicated that calculators could be used in exploration activities.

16.2 Seventy-nine per cent of teachers believed that calculators could be used in problem solving activities.

16.3 Sixty-four per cent of teachers believed that calculators could be used for number pattern work and fifty one per cent in doing algorithms.

16.4 Four per cent of teachers believed that calculators should not be used by primary students.

16.5 Five per cent of teachers were unsure of how students could use calculators in primary mathematics classes.

Influences

Table 4.13: Influences on teacher attitudes (Question 17)

<table>
<thead>
<tr>
<th>Influences</th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>own professional reading</td>
<td>35.2</td>
<td>39.1</td>
<td>28</td>
<td>33.1</td>
</tr>
<tr>
<td>own opinion from teaching students</td>
<td>57.4</td>
<td>69.6</td>
<td>68</td>
<td>63.8</td>
</tr>
<tr>
<td>other teachers</td>
<td>31.5</td>
<td>39.1</td>
<td>48</td>
<td>39.4</td>
</tr>
<tr>
<td>inservice courses</td>
<td>22.2</td>
<td>30.4</td>
<td>18</td>
<td>22.0</td>
</tr>
<tr>
<td>parents of students</td>
<td>3.7</td>
<td>8.7</td>
<td>6</td>
<td>5.5</td>
</tr>
<tr>
<td>other</td>
<td>16.7</td>
<td>39.1</td>
<td>12</td>
<td>18.9</td>
</tr>
</tbody>
</table>
Teachers responded that the main influence in forming their attitudes toward student use of calculators in primary mathematics classes was their "own opinion from teaching students". "Other teachers" and "own professional reading" were rated as the next most reported influences. Twenty-two per cent of teachers saw "inservice courses" as being an influence on their attitudes while five per cent of teachers felt that "parents of students" had an influence on their attitudes. As these teachers were still involved in tertiary study, courses and course lecturers comprised the majority of "other" influences.

Findings:

17.1 The factor that had most influenced the teachers attitudes was their own experiences teaching students. This choice was chosen by 64% of teachers.

17.2 Other teachers (39.4%), own professional reading (33.1%) and inservice courses (22%) were reported as also influencing teacher attitudes.

17.3 Five per cent of teachers considered parents of students as being an influence on their attitudes.

Professional Development Courses

*Table 4.14: Teacher attendance at school based professional development courses on the classroom use of the calculator (Question 18)*

<table>
<thead>
<tr>
<th></th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>11.1</td>
<td>21.7</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>No</td>
<td>85.2</td>
<td>78.3</td>
<td>90</td>
<td>85.5</td>
</tr>
</tbody>
</table>
Overall, few teachers (11%) responded that they had attended a school based professional development course on the classroom use of calculators. It may just have been the case that schools had not identified the use of calculators as being an issue to be discussed at school based professional development courses.

Findings:

18.1 Eleven per cent of teachers had attended professional development courses on the use of the calculator in primary (K-6) mathematics classes.

<table>
<thead>
<tr>
<th>Table 4.15: Willingness to attend professional development courses (Question 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepean</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>yes, within school time only</td>
</tr>
<tr>
<td>yes, within school time or out of school time</td>
</tr>
<tr>
<td>no</td>
</tr>
</tbody>
</table>

When asked if they would be willing to attend school based professional development courses on the use of the calculator 89.8% of teachers responded that they would be with only 9.4% indicating that they were not. Of the 89.8% who said they would attend school based professional development courses 51.2% indicated that they would attend "within school time only" while 38.6% responded that they would attend "within school time or out of school time".

Findings:

19.1 Ninety per cent of teachers responded that they would attend professional development courses on the use of the calculator.
19.2 Of those teachers who would attend professional development courses 51% indicated that they would only attend if it was during school time. Thirty-nine per cent responded that they would attend either in school time or out of school time.

Parent Support

*Table 4.16 Teachers' perceived attitudes of parent support for the student use of calculators (Question 20)*

<table>
<thead>
<tr>
<th></th>
<th>Nepean %</th>
<th>Macarthur %</th>
<th>Strathfield %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13</td>
<td>17.4</td>
<td>24</td>
<td>18.1</td>
</tr>
<tr>
<td>No</td>
<td>27.8</td>
<td>43.5</td>
<td>40</td>
<td>35.4</td>
</tr>
<tr>
<td>Unsure</td>
<td>57.4</td>
<td>34.8</td>
<td>32</td>
<td>43.3</td>
</tr>
</tbody>
</table>

The majority of teachers were "Unsure" of the support from parents for the student use of calculators in primary mathematics classes. Eighteen per cent of teachers believed that parents supported the student use of calculators and 35% of teachers thought that they would not.

Findings:

20.1 Eighteen per cent of teachers indicated that they believed parents would support the student use of calculators.

20.2 Thirty-five per cent of teachers believed that parents would not support the student use of calculators.

20.3 The highest response was from 43% of teachers who were Unsure of parent support towards the student use of calculators.

Classification of Open Comments

Twenty-five per cent of teachers took the opportunity to make a written comment (Appendix D). These were grouped according to the focus of the
comments with a frequency response rate for each campus and overall frequency reported in Table 4.17.

Table 4.17: Summary table of open comments

<table>
<thead>
<tr>
<th>Comments</th>
<th>Nepean</th>
<th>M'arthur</th>
<th>S'field</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>not always appropriate</td>
<td>15</td>
<td>11</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>children can rely too much</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>teach basic facts and processes first</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>used in conjunction with oral, pencil and paper methods</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>calculators make mathematics more accessible</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>some feel using a calculator is cheating</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>sexism towards boys for the use of calculators</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>needs to be addressed more by schools</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>parents' attitudes will differ</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>can be used to check work</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>confusion in parents' minds</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>to be taught for they are a modern piece of technology</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>cost is a hurdle</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>children also need to be trained to think and estimate</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>to be used for computational/problem solving work</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

The open comments indicated a number of personal concerns that teachers needed to express. The one category that needs comment and which eight teachers mentioned was their belief that the basic facts and processes needed to be taught before calculators were introduced.

If the open comments were classified according to teacher support for and against the student use of calculators most supported their use. Issues mentioned by teachers included cost, possible classroom uses of calculators and the attitudes of parents towards their use.
Summary of Findings

Current Use
The majority of teachers responded that they did not have their students presently using calculators. Calculators were primarily used "as the need arose" and "for specific lessons on calculator activities". The responses indicated that calculators were used more "to reinforce estimation skills" and "as a tool for problem solving" than "for computation work". Some teachers indicated that they used calculators "as a reward".

The main reasons for calculators not being used were "there are no calculators available" and "there is no school policy on their use". There were teachers who responded that "they are not relevant for their class". Some believed that "they are too expensive" and a number of teachers responded that they were "unaware of teaching/learning activities". Concern about parent reaction and the organisation needed to use the calculators were seen by few teachers as reasons why they did not have students using calculators.

Teacher Support for Calculators
The study found that the vast majority of teachers supported the student use of calculators in primary mathematics classes. The main reason identified for this support was that "they are a technological tool for use in mathematics". There was further support for the student use of calculators because "children gain confidence through using them" and "they take the focus off computation in doing problems". That "children use them outside the classroom" was identified by many teachers as a further reason for their support for the use of calculators.
Teachers did not support the student use of calculators because "they reduce the need for children to learn basic facts", "children won't learn pencil and paper computational skills" and "they discourage mathematical thinking". There were some teachers who believed that "calculators should only be used in high schools".

**Calculator Policies**

A minority of teachers indicated that their school had a policy on the student use of calculators in primary mathematics classes. Most teachers responded that either their school did not have a policy or they were "Unsure" if their school had a policy.

The schools in which there was a policy on the student use of calculators varied in their focus between allowing all students, K-6, to use them or only those students in Years 4-6.

Teachers indicated that the main reasons their school did not have a school policy on the student use of calculators was that they were "unaware of official policy" and that it was "not seen as a priority".

**Year of Introduction**

There was a wide range of teacher views as to the Year that calculators should be introduced into primary mathematics classes. Slightly more than half the teachers indicated that calculators should be introduced by the end of Year 2. There was not general support for calculators being introduced in Kindergarten and a few teachers believed that calculators should not be introduced at all in primary mathematics classes.
Calculator Uses
Teachers responded that the main uses for calculators were "in exploration activities" and "in problem solving activities". There was also strong support for calculators being used "for number pattern work" and "in doing algorithms".

Influences
The factor that had most influence on teacher attitudes was seen to be their "own opinion from teaching students". This choice rated higher than any other. "Other teachers", "own professional reading" and "inservice courses" were also seen as having an influence on teacher attitudes. "Parents of students" was considered to be an influence by few teachers.

Professional Development Courses
A minority of teachers had attended professional development courses on the use of calculators in primary (K-6) mathematics classes. Nearly all teachers indicated that they would attend such courses with the majority stating they would only attend if the courses were during school time.

Parent Support
Few teachers believed parents would support the student use of calculators. The highest percentage response was that of teachers who were "Unsure" of parents' support towards the use of calculators. Many teachers believed that parents would not support the student use of calculators in primary mathematics classes.

These findings formed the basis of the conclusions and recommendations discussed in Chapter 5.
Chapter 5

DISCUSSION

The purpose of this study was to investigate primary teachers' attitudes toward the student use of calculators in primary (Kindergarten to Year 6) mathematics classes. In order to do this a questionnaire was developed and administered to a sample of teachers completing their fourth year of study towards a Bachelor of Education (Primary). It was assumed that teachers answered the questionnaire with due thought and honesty and it is acknowledged that the findings cannot be generalised to the population of all teachers.

This chapter begins with a general discussion based on the findings of the study followed by a statement of conclusions and recommendations.

General Discussion

In comparing the results of this study to that of Blane and Willis (1986) there was evidence of a growth in support over the last five to six years for the student use of calculators in primary mathematics classes. Teachers strongly supported the introduction of calculators into the primary years. They acknowledged that calculators were mathematical tools available to and used by children outside the classroom and that there were a number of uses for them in mathematics classes.
Teachers who did not support the student use of calculators expressed concern that they reduced the need for children to learn their basic facts and that children would not learn pencil and paper computational skills. This concern was often given specific mention in the teachers' open comments.

"I feel that young children need to learn the basic concepts in maths before using calculators in maths."

"Children can rely on calculators too much."

"Students need to be taught the basic mathematics facts before the calculator is introduced otherwise basic facts will never be learned."

"I feel children need to have basic knowledge of numerals and basic operations before using calculators on a regular basis."

There have been no negative results reported on students' knowledge of basic facts or computational ability in any study where calculators have been used (Bell et al 1983). Teachers need to be made more aware of this and findings of research studies such as CAN (1989) and Hembree and Dessart (1986) which focussed on the student use of calculators and their effects on student achievement.

There was evidence of a growth in teacher support for the earlier introduction of calculators when compared to the report given at ICME 5 which indicated that "a study in 1983 in New South Wales, Australia, 40% of grade 5 students used calculators in the classroom" (Mohyla, 1984, p.69). It was also different to the findings of the UNESCO/CDC (1986) study which found that "the modal age at which it was considered most appropriate to use calculators in mathematics classes was '14', that is in Year 9 in schooling in Australia" (Blane & Willis, 1986, p.12).

However, there was an obvious divergence of opinion amongst teachers concerning the Year of primary school that calculators should be introduced. The teacher responses ranged from Kindergarten to not at all though the
vast majority of teachers believed that they should be introduced by the end of Year 5. This did not support the national calculator policy that recommended their introduction from Kindergarten. Perhaps the majority of teachers did not support the student use of calculators from Kindergarten because they were unsure of their use in the early primary years. This may add support to the need for further investigation of the student use and relevance of calculators from Kindergarten.

The divergence of opinions amongst teachers reinforced the need for clearer directions from educational authorities on the student use of calculators in primary schools, the need for further research into the appropriate use of calculators in the early years and the need for the ongoing professional development of teachers to disseminate research findings and to generate discussion regarding this issue.

The vast majority of teachers supported the student use of calculators in primary mathematics classes but they were currently only being used in a minority of mathematics classes. This should be a concern for two reasons. Firstly, the NSW K-6 Mathematics Syllabus (1989) recommended the student use of calculators from Kindergarten and it is apparent that this was not occurring. Secondly, the teachers who participated in this study were completing their fourth year of study towards a Bachelor of Education (Primary) and it could be assumed that these teachers would be aware of current curriculum policies and yet only a third had their students using calculators.

The reasons given for not using calculators were varied but centred on calculators not being available, no school policy on their use and not being
seen as relevant for the class being taught. These reasons need to be highlighted in the discussion:

1. That there were no calculators available seems to be an oversight in supporting the N.S.W. K-6 Mathematics Syllabus which recommended their use. It also raised the question of why calculators were not available. It may be that the school personnel responsible for making decisions about resources may:
   - not be aware of the syllabus' recommendation,
   - not support that recommendation,
   - not know how to implement the use of calculators in the mathematics classroom,
   - be concerned about parent reaction to the use of calculators.

Perhaps schools believed that it was the responsibility of the educational authorities to supply schools with an adequate number of calculators for teachers to introduce them into their mathematics classes as recommended in the N.S.W. K-6 Mathematics Syllabus (1989). The lack of calculators was identified by teachers as a major reason why students were not using them in primary mathematics classes.

2. Schools need to develop policies that support and reflect the relevant syllabus documents. It appeared that a number of schools have not yet developed a calculator policy and this was identified by teachers as a reason why students were not using calculators.

The student use of calculators has generated such community discussion over time that schools need to discuss the issue and develop a school policy on their use.
3. Many teachers did not see calculators as being relevant for their class. There were 26 teachers who indicated this and when identified 12 of these teachers were Kindergarten teachers. In the total study there were 16 teachers who said that they were currently teaching Kindergarten. Of these, 12 said that calculators were not relevant for their students. This needs further investigation for if this was the case amongst all Kindergarten teachers it would be difficult for educational authorities to implement a state and national policy on calculators that recommended their introduction from Kindergarten. It may also be that since many schools have not developed a policy on the student use of calculators, teachers have not discussed their place in Kindergarten, leading teachers to believe that they were not relevant for the first year of schooling. There needs to be further study undertaken to investigate the use of calculators in Kindergarten in order to gauge their relevance for this grade. It may well be that the introduction of calculators into Kindergarten is not supported by teachers or the community.

These three issues must be addressed by educational authorities, researchers and schools if teachers are to use calculators effectively and efficiently in their mathematics classes.

The sample for this study comprised primary teachers who were completing their Bachelor of Education (Primary) which limited the generalisation of findings to all primary teachers. A broader study needs to be carried out to investigate the support amongst teachers of varying backgrounds towards the student use of calculators. Such teachers could be those in executive positions within the school, teachers in various classes and teachers with varying years of experience.
The majority of teachers involved in this study were female in their first five years of teaching. Perhaps the lack of student use of calculators could be due to the teachers just beginning their careers and they may be more concerned with surviving the day to day rigours of teaching. Perhaps they will begin to have students use calculators more as they gain experience and confidence in their teaching.

It could also be argued that these teachers were among the most recent graduates from teacher training courses and that the mathematics units within these tertiary courses should have prepared them to use calculators in their mathematics lessons. These courses need to be evaluated in the light of recent research and syllabus documents concerning the issue of calculator use to better prepare initial teachers for the role of calculators in the primary mathematics curriculum.

Teachers indicated that a number of schools did not have policies on calculator use mainly because they were not aware of official policy, were waiting for directions or it was not seen as a priority. Concern should be expressed that schools were "unaware of official policy" or "waiting for directions for their use in schools" for they have been given an official syllabus and directions in the form of the NSW K-6 Mathematics Syllabus (1989). These directions may not have been effectively communicated to teachers through the syllabus and clearer statements may need to be made. It could also be that teachers and schools have not acquainted themselves with the syllabus.

In NSW the K-6 Mathematics Syllabus (1989) and nationally the calculator policy (CDC/AAMT, 1987) have recommended the use of calculators from Kindergarten. One could have assumed that school policies would reflect
these statements. This was not always the case. School calculator policies varied regarding the years in which students were allowed to use them. Some had them available from Kindergarten others from Year 4. A clear policy statement should be developed by schools on how and when calculators can be used by students. Such a policy needs to be made available to teachers, students and parents so that a positive direction regarding their use is given to all within the school community.

A number of teachers at the Strathfield campus indicated that their school policy did not introduce calculators into the early years of primary school. As these teachers were predominantly employed in Catholic schools it could be that many Catholic schools introduce the student use of calculators from Year 4. This issue needs further investigation.

The issue of the student use of calculators has been a community concern for twenty years. With the increasing student access to calculators and the directions given to its place in the mathematics syllabus the development of a school calculator policy should be seen as a priority and discussion of the issue needs to be entered into by school communities.

Schools and teachers need a research base for these discussions. Hembree and Dessart’s (1986) meta-analysis considered only 16 studies relating to grades Kindergarten to Year 3 (Saxon, 1987). The work carried out and reported through the CAN study (1989) focussed on the early primary years. The findings from this study need to be disseminated to teachers and schools.

McIntosh (1990) has suggested having classroom teachers investigate the use of calculators in their classrooms followed by the dissemination of their
findings to other teachers. This was a worthy suggestion and it would have wide support. Consideration would have to be given to the individual's teaching philosophy and classroom climate for such a study. It needs to be remembered that the CAN study (1989) did not just introduce calculators into the mathematics classroom. The teaching in this study was based on an open-ended approach to the teaching of mathematics using various problems and investigations with calculators being available at all times for the children.

Teachers have stressed the importance of school based professional development courses and their willingness to attend if they were organised during school time. Schools need to respond to this stated need and organise such courses through their staff development plan. To assist teachers and schools in their discussion of this issue educational authorities could disseminate research findings to schools. Professional groups either nationally such as the Australian Association of Mathematics Teachers (AAMT) or state based such as the Mathematical Association of New South Wales (MANSW) could investigate ways in which they could assist schools with structured workshop material and dissemination of research findings.

The majority of teachers indicated that they would attend such courses within school time only. This was similar to Blane and Willis' (1986) finding that "the most frequently suggested format was for school-based workshops lasting either half or a whole day" (p.24). Thus for all teachers to support such courses and attend they need to be offered during school time. Such a view of staff development courses has been common over the last few years and reflective of the industrial situation with teacher unions being supportive of school based professional development courses held only during school time (Sharkey, 1990).
The responses to what influences helped form teacher attitudes may have suggested a means by which curriculum change could be implemented. Teachers responded most strongly that their experiences with their students was the most forceful influence. Thus teachers should have their students work with calculators to gauge their usefulness. The results of such work could be followed by discussion among teachers in school based workshops with research material or commentaries on the issue being available to supplement the teachers' classroom experiences.

This could become the focus of a calculator based study which involved teachers in observing and working with their students using calculators. The study could be similar to the structure of the CAN (1989) project. The purpose of this study would be to gauge the relevance of the student use of calculators in primary classes. The observations from this classroom research could be followed by discussion with other teachers. As well as these discussions and interchange of ideas teachers could be given access to research material as they continued to explore the place of calculators in their mathematics classes.

It was apparent that teachers were aware of the parent concern over the student use of calculators as many teachers believed that parents would not support the student use of calculators. Such a view was found in Blane and Willis' study (1986) which reported that at the upper primary level "parents were perceived to be strongly against" (p.8) the use of calculators. There was also evidence that teachers were uncertain at the present time of how parents viewed the student use of calculators in the primary years. Such a degree of uncertainty is another area in need of investigation perhaps
focused on 'Parent views on the student use of calculators in primary mathematics classes'.

Calculators are here to stay and there was strong support from teachers in this study for their use by students in the primary years. Though presently, a minority of teachers had their students using calculators. The reasons teachers gave for not having their students using calculators need to be addressed by educational authorities if they are to be introduced effectively into the primary mathematics curriculum.
Conclusions

This study investigated teacher attitudes towards the student use of calculators in primary mathematics classes. The findings from this study have been generalised to the following conclusions.

1. Calculators were not in general use in the primary grades.

2. There was not the same support for calculators being used in computational work as there was for it as a tool for problem solving and to reinforce estimation skills.

3. Teachers were not using calculators primarily because there were none available and/or there was no school policy on their use.

4. There were a number of teachers who did not see calculators as being relevant for their class.

5. There was strong support amongst teachers for the use of calculators in primary mathematics classes.

6. Teachers did not see that the use of calculators would reduce individual differences.

7. Teachers were concerned that calculators reduced the need for children to learn the basic facts and that they would not learn pencil and paper computational skills.

8. There were many schools that did not have a stated calculator policy.

9. There was a difference in stated school policies as to the student use of calculators. Some stated all students Kindergarten to Year 6 should have access while others stated only students from Year 4.

10. Educational authorities had not effectively communicated to schools their policies on the student use of calculators in primary mathematics classes.
11. There was not general support among teachers that calculators should be used from Kindergarten.

12. The main influence on teachers in forming their attitudes was their own opinion from teaching students.

13. School based professional development courses on the use of calculators in their primary mathematics classes had not been offered to teachers.

14. The vast majority of teachers were willing to attend school based professional development courses. Of these teachers, most would attend courses only within school time.

15. Most teachers were either unsure of parents' attitudes towards the student use of calculators or felt that parents would not support their use.
Recommendations

Based on the findings that have emerged from this study and the conclusions that have been drawn, the following recommendations are made.

A. Recommendations for Curriculum Change

1. Educational authorities must communicate more effectively syllabus directions for student use of calculators in primary mathematics classes. There should be a statement issued to schools by the relevant educational authorities clarifying the role of calculators in primary mathematics classes.

2. Educational authorities need to take on the responsibility or liaise with professional bodies to update schools and teachers with emerging research findings. This could be done in the form of a research findings bulletin published twice a year outlining the possible implications for the primary mathematics syllabus. This could be a joint publication from relevant educational authorities and professional bodies such as the NSW Board of Studies and the Mathematics Association of New South Wales.

3. Calculators should be made available for student use in primary mathematics classes. Schools could be supplied with calculators, schools could purchase calculators or students could purchase calculators as part of their school requirements.

4. Schools need to develop a policy on the student use of calculators. This policy needs to be developed through discussion between teachers and parents.
B. Recommendations for Professional Development Courses

1. Teachers could be offered structured school based professional development courses on the use of calculators in primary mathematics classes. These courses would need to be offered within school time for all teachers to attend. Such courses would be part of a school's staff development plan.

These could be structured courses involving discussion sessions, source material and classroom research tasks for teachers and students. The teacher/student observations from the research tasks could form part of each discussion session. Outcomes from such a course could be disseminated to other schools within a region across the state or nationally.

C. Recommendation for Tertiary Courses

1. Teaching students at all tertiary institutions and at all levels of study should use calculators throughout their course and be made aware of its use in primary mathematics classes.

D. Recommendations for Future Research

1. A research study be set up across Australia or within a state to investigate the student use of calculators in primary mathematics classes, initially, over a six to twelve month period. This study to comprise a range of schools and classes from Kindergarten to Year 6. The study to focus on calculators being available to all students as part of the mathematics class with the teacher/student use of calculators being recorded and the findings reported.

The research needs to be school based with calculators being available to students at all times. The study would be directed at gauging the usefulness and relevance of calculators to various grades. Student access
to the calculators would be complemented with specific calculator lessons as the students or teachers identify a need. Teachers and students would be asked to record their work with the calculators, the results of which will be discussed amongst other teachers in school based workshops with research material or commentaries on the issue being available to supplement the teachers' classroom experiences.

2. The findings of such a study to be incorporated into the development of state and national syllabus statements leading to a calculator integrated mathematics curriculum (K-12).

3. The findings from research studies have suggested that parents do not support the student use of calculators in primary mathematics classes. This study suggested that there was uncertainty among teachers as to parent attitudes.

In order to gauge community reaction a study be set up to investigate community attitude towards the student use of calculators in primary mathematics classes. Such a study would be school based and be set up with discussion workshop sessions being given for parents. These sessions could include semi-structured interviews being given before and after the workshops to gauge parent attitudes towards the use of calculators and to gauge any change to parent attitudes that may come about as a result of their participation in the workshops.
Appendix A

Pilot Questionnaire
August 28, 1989

Dear Colleague,

A major issue in primary mathematics being discussed in the community is the student use of calculators in primary schools.

With a new K-6 Mathematics Syllabus having just been given ministerial approval your opinion on the issue is being sought.

The responses that you give will be used to give education authorities direction as to teachers' attitudes towards the student use of calculators in K-6 mathematics classes.

The information given will be treated confidentially; you are not asked to give your name or to identify your school.

Thank you for taking the time to state your opinion.

Yours faithfully,

P. Howard
Lecturer in Mathematics
TEACHERS' ATTITUDES TOWARD THE STUDENT USE OF CALCULATORS IN PRIMARY (KINDERGARTEN - YEAR 6) MATHEMATICS CLASSES

Circle the appropriate response.

1. What sex are you?
   a) male  1
   b) female  2

2. How long have you been teaching?
   a) 0 - 5 years  1
   b) 5 - 10 years  2
   c) 10 - 15 years  3
   d) more than 15 years  4

3. Are you a:
   a) classroom teacher  1
   b) casual teacher  2
   c) teaching executive  3
   d) non-teaching executive  4
   e) other,
      please specify

4. If you are a classroom teacher, the class you are currently teaching is:
   a) Kindergarten  1
   b) Year 1  2
   c) Year 2  3
   d) Year 3  4
   e) Year 4  5
   f) Year 5  6
   g) Year 6  7
   h) Other class,
      please specify type and grouping
      e.g. composite Yr 5/6

5. What is the range of classes that you usually teach?
   a) K - 2  1
   b) 3 - 6  2
   c) K - 6  3

6. Do you presently have students using calculators in your mathematics classes?
   a) Yes  1
   b) No  2

Appendix A: Pilot Questionnaire
If **YES** how do the children use them?  
(You may circle more than one response)  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) children have free access to them as the need arises</td>
<td>1</td>
</tr>
<tr>
<td>b) specific lessons on calculator activities</td>
<td>1</td>
</tr>
<tr>
<td>c) as a tool for problem solving</td>
<td>1</td>
</tr>
<tr>
<td>d) for computation work</td>
<td>1</td>
</tr>
<tr>
<td>e) to reinforce estimation skills</td>
<td>1</td>
</tr>
<tr>
<td>f) as a reward</td>
<td>1</td>
</tr>
<tr>
<td>g) other, please specify</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-13</td>
</tr>
</tbody>
</table>

If **NO** why not? (You may circle more than one response)  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) too expensive</td>
<td>1</td>
</tr>
<tr>
<td>b) not relevant for my class</td>
<td>1</td>
</tr>
<tr>
<td>c) too difficult to organise</td>
<td>1</td>
</tr>
<tr>
<td>d) concerned about parent reaction</td>
<td>1</td>
</tr>
<tr>
<td>e) no calculators available</td>
<td>1</td>
</tr>
<tr>
<td>f) no school policy on their use</td>
<td>1</td>
</tr>
<tr>
<td>g) unaware of teaching/learning activities using calculators</td>
<td>1</td>
</tr>
<tr>
<td>h) other, please specify</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14-21</td>
</tr>
</tbody>
</table>

7. Are you supportive of the student use of calculators, in primary (K-6) mathematics classes?  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>1</td>
</tr>
<tr>
<td>b)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>

If **YES** why? (You may circle more than one response)  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) they speed up children's work (saves time)</td>
<td>1</td>
</tr>
<tr>
<td>b) they are a technological tool for use in mathematics</td>
<td>1</td>
</tr>
<tr>
<td>c) helps to reduce individual differences</td>
<td>1</td>
</tr>
<tr>
<td>d) children use them outside the classroom</td>
<td>1</td>
</tr>
<tr>
<td>e) they can help develop problem solving skills</td>
<td>1</td>
</tr>
<tr>
<td>f) children gain confidence through using them</td>
<td>1</td>
</tr>
<tr>
<td>g) take the focus off computation</td>
<td>1</td>
</tr>
<tr>
<td>h) increases children's motivation</td>
<td>1</td>
</tr>
<tr>
<td>i) other, please specify</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23-31</td>
</tr>
</tbody>
</table>

If **NO** why not? (You may circle more than one response)  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) reduces need for children to learn basic facts</td>
<td>1</td>
</tr>
<tr>
<td>b) discourages mathematical thinking</td>
<td>1</td>
</tr>
<tr>
<td>c) calculators should only be introduced in high schools</td>
<td>1</td>
</tr>
<tr>
<td>d) children won't learn pencil and paper computational skills</td>
<td>1</td>
</tr>
<tr>
<td>e) too expensive</td>
<td>1</td>
</tr>
<tr>
<td>f) other, please specify</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32-37</td>
</tr>
</tbody>
</table>

8. Does your school have a policy on the student use of calculators in primary mathematics classes?  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>
If **YES** what is its focus?
- a) children K-6 are allowed to use them 1
- b) children 4-6 are allowed to use them 2
- c) children are not allowed to use them 3
- d) other, please specify ___________________________ 4

If **NO** why not? (You may circle more than one response)   
- a) not seen as a priority Yes No 1 2
- b) unaware of official policy 1 2
- c) need parental opinion 1 2
- d) waiting for directions for their use in schools 1 2
- e) other, please specify ___________________________ 1 2

9. From what class do you believe that students should use calculators in mathematics classes?
- a) Kindergarten 1
- b) Year 1 2
- c) Year 2 3
- d) Year 3 4
- e) Year 4 5
- f) Year 5 6
- g) Year 6 7
- h) not at all in primary class 8

10. How do you believe calculators can be used by students in primary (K-6) mathematics classes? (You may circle more than one response)   
- a) in problem solving activities Yes No 1 2
- b) in doing algorithms 1 2
- c) in exploration activities 1 2
- d) for number pattern work 1 2
- e) I am not too sure of how they can be used 1 2
- f) I don't think they should be used 1 2
- g) other activities, please specify ___________________________ 1 2

11. What influences have formed your attitudes towards the student use of calculators in primary (K-6) mathematics classes? (You may circle more than one response)   
- a) own professional reading 1 2
- b) own opinion from teaching students 1 2
- c) other teachers 1 2
- d) in-service courses 1 2
- e) parents of students 1 2
- f) other influences, please specify ___________________________ 1 2

12. Have you attended any in-service courses on the use of the calculator in primary (K-6) mathematics classes?   
- a) Yes 1
- b) No 2

13. Would you attend such courses?
Appendix A: Pilot Questionnaire

14. In your opinion do parents generally support the student use of calculators in primary (K-6) mathematics classes?
   a) Yes 1
   b) No 2

I would appreciate any other comments that you would like to make about the student use of calculators in primary (K-6) mathematics classes.

Thank you for your co-operation.

Peter Howard
Lecturer in Mathematics
Appendix B

Questionnaire
May, 1990

Dear Colleague,

A major issue in primary mathematics being discussed in the community is the student use of calculators in primary schools.

With the new K-6 Mathematics Syllabus having been released to NSW schools last October your opinion on this issue is being sought.

The responses that you give will be used to give education authorities direction as to teachers' attitudes towards the student use of calculators in K-6 mathematics classes.

The information given will be treated confidentially; you are not asked to give your name or to identify your school.

Thank you for taking the time to state your opinion.

Yours faithfully,

P. Howard
Lecturer in Mathematics
### TEACHERS' ATTITUDES TOWARD THE STUDENT USE OF CALCULATORS IN PRIMARY (KINDERGARTEN - YEAR 6) MATHEMATICS CLASSES

**Circle the appropriate response.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What sex are you?</td>
<td>a) male</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) female</td>
<td>2</td>
</tr>
<tr>
<td>2. How long have you been teaching?</td>
<td>a) 0 - 5 years</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) 6 - 10 years</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c) 11 - 15 years</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>d) more than 15 years</td>
<td>4</td>
</tr>
<tr>
<td>3. Are you currently a:</td>
<td>a) permanent classroom teacher</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) casual teacher</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c) teaching executive</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>d) non-teaching executive</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>e) other, please specify</td>
<td>5</td>
</tr>
<tr>
<td>4. If you are a classroom teacher, the class you are currently teaching is:</td>
<td>a) Kindergarten</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) Year 1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c) Year 2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>d) Year 3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>e) Year 4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>f) Year 5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>g) Year 6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>h) Other class, please specify type and grouping e.g. composite Yr 5/6</td>
<td>8</td>
</tr>
<tr>
<td>5. What is the range of classes that you usually teach?</td>
<td>a) K - 2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) 3 - 6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c) K - 6</td>
<td>3</td>
</tr>
<tr>
<td>6. Do you presently have students using calculators in your mathematics classes?</td>
<td>a) Yes (If Yes, go to Question 7)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b) No (If No, go to Question 8)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c) Currently not teaching mathematics</td>
<td>3</td>
</tr>
</tbody>
</table>
7. If YES to Question 6, how do the children use them? (You may circle more than one response)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) as the need arises</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) for specific lessons on calculator activities</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c) as a tool for problem solving</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d) for computation work</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e) to reinforce estimation skills</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f) as a reward</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g) other, please specify</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) too expensive</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) not relevant for my class</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c) too difficult to organise</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d) concerned about parent reaction</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e) no calculators available</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f) no school policy on their use</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g) unaware of teaching/learning activities using calculators</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>h) other, please specify</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

8. If NO to Question 6, why not? (You may circle more than one response)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) too expensive</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) not relevant for my class</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c) too difficult to organise</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d) concerned about parent reaction</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e) no calculators available</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f) no school policy on their use</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g) unaware of teaching/learning activities using calculators</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

9. Are you supportive of the student use of calculators in primary (K-6) mathematics classes? (You may circle more than one response)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Yes (If Yes, go to question 10)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) No (If No, go to question 11)</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

10. If YES to Question 9, why? (You may circle more than one response)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) they speed up children's work (saves time)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) they are a technological tool for use in mathematics</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c) they help to reduce individual differences</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d) children use them outside the classroom</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e) they can help develop problem solving skills</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f) children gain confidence through using them</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g) they take the focus off computation in doing problems</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>h) I feel they increase children's motivation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>i) other, please specify</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) they reduce the need for children to learn basic facts</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b) they discourage mathematical thinking</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c) calculators should only be introduced in high schools</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d) children won't learn pencil and paper computational skills</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e) they are too expensive</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f) other, please specify</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
12. Does your school have a policy on the student use of calculators in primary (K-6) mathematics classes?
   a) Yes (If yes, go to question 13) 1
   b) No (If no, go to question 14) 2
   c) Unsure 3

13. If YES to Question 12, what is the focus of the policy?
   a) children K-6 are allowed to use them 1
   b) children 4-6 are allowed to use them 2
   c) children are not allowed to use them 3
   d) other, please specify 4

14. If NO to question 12, why not?
   (You may circle more than one response)
   Yes No
   a) not seen as a priority 1 2
   b) unaware of official policy 1 2
   c) need parental opinion 1 2
   d) waiting for directions for their use in schools 1 2
   e) other, please specify

15. From what class do you believe students should use calculators in primary mathematics classes?
   a) Kindergarten 1
   b) Year 1 2
   c) Year 2 3
   d) Year 3 4
   e) Year 4 5
   f) Year 5 6
   g) Year 6 7
   h) not at all in primary classes 8

16. How do you believe calculators can be used by students in primary (K-6) mathematics classes?
   (You may circle more than one response)
   Yes No
   a) in problem solving activities 1 2
   b) in doing algorithms 1 2
   c) in exploration activities 1 2
   d) for number pattern work 1 2
   e) unsure 1 2
   f) I don't think they should be used 1 2
   g) other activities, please specify

17. What influences have formed your attitudes toward the student use of calculators in primary (K-6) mathematics classes?
   (You may circle more than one response)
   Yes No
   a) own professional reading 1 2
   b) own opinion from teaching students 1 2
   c) other teachers 1 2
   d) in-service courses 1 2
   e) parents of students 1 2
   f) other influences, please specify
18. Have you attended any school based professional development courses on the use of the calculator in primary (K-6) mathematics classes?
   a) Yes 1 59
   b) No 2

19. Would you attend such courses?
   a) yes, within school time only 1 60
   b) yes, within school time or out of school time 2
   c) no 3

   If NO why not?
   Please specify ________________________________

20. In your opinion, do parents generally support the student use of calculators in primary (K-6) mathematics classes?
   a) Yes 1 61
   b) No 2
   c) Unsure 3

I would appreciate any other comments that you would like to make about the student use of calculators in primary (K-6) mathematics classes.

______________________________________________________________

Thank you for your time and co-operation.

Peter Howard
Lecturer in Mathematics
Appendix C

Coded Items For Analysis
Appendix C: Coded Items for Analysis

Items for Questionnaire

HOWARD.VAR
VAR01 SEX
VAR02 TIME
VAR03 TYPE
VAR04 CLASS
VAR05 RANGE
VAR06 USE
VAR07 FREE ACC
VAR08 SPEC LESS
VAR09 TOOL
VAR10 COMP
VAR11 EST
VAR12 REWARD
VAR13 OTH1
VAR14 TOO EXP
VAR15 NOT REL
VAR16 TOO DIFF
VAR17 CONCERN
VAR18 NONE
VAR19 NO OFF POL
VAR20 UNAWARE
VAR21 OTH2
VAR22 SUPPORT
VAR23 SPEED
VAR24 TECH TOOL
VAR25 REDUCE
VAR26 OUTSIDE
VAR27 DEVELOP PS
VAR28 GAIN CON
VAR29 OFF COMP
VAR30 MOTIVATES
VAR31 OTH3
VAR32 BAS FAC
VAR33 DISCOV
VAR34 HS
VAR35 NO PP
VAR36 EXP
VAR37 OTH4
VAR38 POL
VAR39 FOCUS
VAR40 NOT PRI
VAR41 OFF POL
VAR42 PAR OP
VAR 43 WAIT DIR
VAR44 OTH5
VAR45 START
VAR46 PS
VAR47 ALG OR
VAR48 EXPLOR
VAR49 PATTS
VAR50 UNSURE
VAR51 NOT AT ALL
VAR52 OTH6
VAR53 READING
VAR54 OWN OP
VAR55 TEACHERS
VAR56 COURSES
VAR57 STU PAR
VAR58 OTH INF L
VAR59 HATT
VAR60 WATT
VAR61 PARS
Appendix D

Open Comments
Nepean Open Comments

"Children can come to rely on calculators too much."

"Students need to be taught the basic mathematics facts before the calculator is introduced otherwise basic facts will never be learned."

"Prior to attempting to teach manipulation of a calculator, basic mathematical skills must first be established. Use of the calculator should occur as an extension to the teaching of such facts."

"They should be used in conjunction with oral work, pencil and paper work and problem solving pattern work. They are highly motivating and all children can feel success. We can teach them the basic facts at the same time. Play prehistoric maths i.e., long division, big multiplications. They should be used as a facilitator to learning."

"Calculators are readily accepted and mastered by students with a poor self-image about maths. This makes maths more accessible and acceptable to more students and increases its availability as a tool subject."

"Parents and some children feel that using a calculator is cheating."

"There is sexism towards the use of calculators. This has been in favour of boys."

"As long as other methods are shown, calculators are fine in primary schools even at Kindergarten level as discovery activities."
"I feel children need to have basic knowledge of numerals and basic operations before using calculators on a regular basis. I would only introduce calculators to infants classes on an exploratory level."

"Parents attitudes towards calculators would differ from region to region plus their own experiences with calculators would influence them."

"Needs to be addressed more by schools e.g. inserviceing in the application and activities of the calculator."

"I feel that young children need to learn the basic concepts in maths before using calculators in maths. I do believe primary children need to be aware of calculators due to technology changes."

"Only used once mathematical processes known. Once process is routine calculators increase speed and ability to deal with real world numbers."

"Like computers they are here to stay. Children should use them after they have learnt the processes that you teach."

"Children need to learn properly and responsibly how to use them as they are a modern piece of technology not unlike using games and activities or computer."
Macarthur Open Comments

"Confusion in some parents minds about what place calculators hold in the syllabus."

"I see them as a useful tool to be used in accordance with learned algorism. Parents are worried because they believe pupils will lose the skill of thinking when solving problems."

"Children need to use them - it takes the chore out of problem solving - however, confidence in working algorithms etc., without calculators is also essential."

"They're good as long as children are still trained to think and estimate, rather than believe the calculator."

"I feel children should learn to use the normal and calculator procedures in problem solving so they have a variety of methods in working through problems. They can choose the most appropriate methods for themselves. Parents could do parent inservice on calculators in school time."

"For calculators to be effective there must be sufficient supply. At the present time they appear to be too expensive."

"Calculators are now essential to Maths but they must have the concept without the calculator first - in case the batteries go flat."

"Should be used for computational and problem solving."
"I usually do not allow them to use a calculator unless they have the answer worked out before checking it with a calculator. Children in Year 6 should become familiar with calculators before going to high school."

"Should be encouraged more widely. Own experience is NOT indicative of other teachers at my own school."

"Unfortunately cost seems a major hurdle and with underprivileged children having none at home is a problem."
Strathfield Open Comments

"I think they are an inevitable tool in the mathematics process but I believe they need to learn the basics before utilizing the calculator."

"I feel that it is important for students to move with the technology of the times. I guess once upon a time there were no slide rules or log tables - now they are part of life and not questioned so also for calculators, computers, etc..."

"Children should not rely on the use of calculators as this destroys their ability to do mental calculations when a calculator is unavailable."

"They are a valuable resource for checking particularly in K-2."

"The students can check their own work using calculators."

"Not always appropriate"
Bibliography


Basic Learning in Primary Schools Program. (1986). Calculators in the primary school - a pressing concern. Sydney: Commonwealth Schools Commission and N.S.W. Department of Education.


Bibliography


NSW Department of School Education. (1989). *K-6 mathematics syllabus.* Sydney: Department of School Education.


PRIMARY TEACHERS' ATTITUDES TOWARD THE STUDENT USE OF CALCULATORS IN PRIMARY (KINDERGARTEN-YEAR 6) MATHEMATICS CLASSES

MASTER OF EDUCATION THESIS

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PLEASE NOTE

The greatest amount of care has been taken while scanning this thesis,

and the best possible result has been obtained.
CERTIFICATE OF ORIGINALITY OF THESIS

I certify my authorship of the Thesis submitted today entitled:

PRIMARY TEACHERS' ATTITUDES TOWARD THE STUDENT USE OF CALCULATORS IN PRIMARY (KINDERGARTEN-YEAR 6) MATHEMATICS CLASSES

in terms of the Statement of Requirements for Thesis in Masters' Programs issued by the Committee.

Signature of Author: .......................................................... Date:..........................
Abstract

The last fifteen years has seen an increase in the availability of calculators for use by schools and students. Educational authorities in Australia, the United States of America and the United Kingdom have come to recommend the student use of calculators from Kindergarten upwards. This recommendation has attracted continuing controversy, specifically regarding the use of, calculators in primary schools. Such controversy prompts an important question: What views do primary teachers themselves hold on this issue?

This report examined the findings of a study into primary teachers' present attitudes toward the student use of calculators in primary (Kindergarten-Year 6) mathematics classes. Data were collected from a questionnaire administered during 1990 to a sample of teachers undertaking their fourth year of study for a Bachelor of Education (Primary) at three university campuses in New South Wales, Australia.

The results of the study showed 32% of primary teachers had their students using calculators, though 85% supported the student use of calculators in primary mathematics classes. Teachers indicated that calculators were not being used because either none were available, there was no school policy on their use and/or they were not considered relevant for the class being taught.

Those teachers who supported the primary student use of calculators believed that calculators are a technological tool for use in mathematics, that they increase children's' confidence, they take the focus off computation in doing problems and that children use them outside the
classroom. It was found that of these teachers, 55% supported the introduction of calculators before the end of Year 2. A total of 4% did not support their use at all in primary mathematics classes.

This study concluded that there was not overall support from primary teachers for the introduction of the calculator into Kindergarten as recommended in the 'National Statement on the use of Calculators for Mathematics in Australian Schools' (1987). There emerged two major recommendations from this study:

1. Each primary school needed to develop a policy on the student use of calculators.

2. A study be undertaken into the effectiveness of student use of calculators in Australian primary mathematics classes. The findings of which could lead to the development of a national calculator integrated primary mathematics curriculum.
Preface

The fact that this work was completed is in no small way due to the assistance given by a number of people. Firstly the advice and direction from Dr Beth Southwell and Dr Mon Khamis whose teaching and analytical comments have both taught me much and developed the quality of my work.

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Finally, to my dear wife Michele Kathryn Howard (1951-1990) whose strength, help and encouragement has enabled this thesis to be finished and to whom this work is dedicated.
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AAMT    Australian Association of Mathematics Teachers
AEC     Australian Education Council
AMEP    Australian Mathematics Education Project
BLIPS   Basic Learning in Primary Schools Program
CAN     Calculator-Aware Number curriculum
CDC     Curriculum Development Centre
FASTS   Federation of Australian Scientific and Technological Societies
ICME 5  Fifth International Congress of Mathematics Education
MANSW   Mathematical Association of New South Wales
NCTM    National Council of Teachers of Mathematics
PrIME   Primary Initiatives in Mathematics Education
PRISM   Priorities in School Mathematics
UNESCO  United Nations Educational, Scientific and Cultural Organisation