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Number sense in urban Aboriginal primary students

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USE OF THESIS

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ABSTRACT

This paper examines the number sense of urban Aboriginal primary students attending school in Perth. The subjects were asked to complete a test designed to assess their number sense, which has been defined as "[a] propensity for and an ability to use numbers and quantitative methods as a means of communicating, processing and interpreting information" (McIntosh, Reys, Reys, Bana & Farrell, 1997, p. 61). It involves an intuitive understanding about numbers and how to use them in practical ways. Some subjects were also interviewed, so that a greater understanding of their number sense could be gained.

It was found that there was a difference in the scores on the number sense test of the Aboriginal subjects and the scores of an Australian sample tested in an earlier study (McIntosh, Reys, Reys, Bana & Farrell, 1997). The Aboriginal sample group scored lower. However, there was a non-Aboriginal sample group tested in the current study. The number sense test scores of this group were not significantly different to those of the Aboriginal subjects.

Several reasons, which are also seen as being limitations to this study, have been suggested for these results. The sample size was limited in the present study. The subjects were not randomly selected, and are not

representative of the population. There are factors associated with the location of the school which are likely to influence the general academic performance of the subjects, as well as their performance on the number sense test. These factors include unemployment, low incomes and lack of formal qualifications in the homes of some of the subjects. Language differences and absenteeism were also considered as possible influences on the performance of the subjects on the number sense test. Some interesting cultural issues also arose, suggesting several avenues for further study.

The study has supported previous research into the informal learning styles of Aboriginal people. Some important implications for classroom mathematics instruction arise from this. The informal learning styles need to be recognised and utilised in the classroom, so that Aboriginal students can focus more on the mathematics content of lessons. This includes presenting examples that are relevant and contain familiar objects or situations. The mathematical strengths of Aboriginal people also need to be recognised, valued and incorporated into the mathematics instruction in the classroom.

Although limited in several ways, this research is valuable for the instruction of Aboriginal students in mathematics. It confirms and supports findings in previous research. Further research would be useful, and several suggestions as to the directions this could take are made.

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

(ii) contain any material previously published or written by another person except where due reference is made in the text; or

(iii) contain any defamatory material.

[redacted]

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CONTENTS

TABLES

Chapter 1

Introduction

This study is concerned with the number sense of urban Aboriginal primary students in Perth. McIntosh, Reys, Reys, Bana and Farrell define number sense as "[a] propensity for and an ability to use numbers and quantitative methods as a means of communicating, processing and interpreting information" (1997, p. 61). It involves understanding about numbers and being able to use them in practical ways. The Number Sense Test developed by McIntosh et al. (1997) is used in this study to assess the number sense of Aboriginal students attending a government primary school in metropolitan Perth. The results are compared to those achieved by an Australian sample in the study undertaken by McIntosh et al.

A general discussion of the historical background of Aboriginal people will reveal some of the ways in which they used mathematics, and how the need for mathematical skills has changed since the British colonisation of Australia.

Background

From the time of the British colonisation of Australia, Aboriginal people have experienced varying degrees of industrialisation and technological change. Any discussion of Aboriginal cultures must acknowledge these varying degrees, from a traditional life-style minimally influenced by Western culture to a lifestyle seemingly lived in much the same way as any non-Aboriginal Australian. In the present day, the diversity among Aboriginal cultures also includes the extent to which Western ideas and practices have been adopted.

Aboriginal cultures have traditionally not needed numbers and the operations done with numbers. Aboriginal life was governed by relationships, both with people and nature. Group dynamics and social organisation were important, and governed the actions of Aboriginal people. In traditional Aboriginal life, physical survival depended partly on a highly developed spatial awareness, including orientation in the physical environment and a sense of direction (Graham, 1987, p. 95; Kearins, 1984, p. 26; Currie, Kissane, & Pears, 1992, p. 16). There was little need for numbers, counting and numerical operations.

Changes in lifestyle for most Aboriginal people, brought about by the British colonisation of Australia, have created a need for using numbers. Numbers are now used in

daily life in a variety of ways. Managing money, shopping for household requirements, paying bills, and fuelling a car require an understanding of money and its value, as well as proficiency with calculations involving money. Planning how much is needed of a particular item, for example food and petrol, requires skills of mental calculation, such as estimating. These fundamental needs are similar for most people, whether living in remote locations or in city dwellings, although the extent may differ. Aboriginal people in urban environments may have a greater need for the numerical aspect of mathematics due to their employment, or a greater reliance on technology, or simply a different lifestyle.

However, having the need to use mathematics and living in a mathematical and technological society does not guarantee success in understanding or succeeding in mathematics education in school. Berndt (cited in Bishop, 1994, p. 50) stated that:

> It has become, over the years, abundantly clear that we cannot ignore the cultural and family backgrounds of our pupils; in presenting them with a different way of life, these have to be taken into account.

Culture is learned, and each culture differs in its values and what it holds as being important. Most non-Aboriginal Australian children enter school with a basic understanding of what it is all about and what is expected of them. They have already been exposed, in the home, to "informal

processes of learning about their own society and culture, including something about schools and teachers and books" (Jacobs, 1979, p. 1). They have also been exposed to simple, everyday mathematics, such as counting and basic addition, by parents who talk conversationally with their children and who see the value in mathematics. Early school programs are based on the assumption that "a raft of educationally useful processes have been established prior to children commencing formal schooling" (Jones, Kershaw & Sparrow, 1995, p. 33). Aboriginal children do not lack the ability to master mathematics, but they may be at "a cultural disadvantage when learning mathematics" (Bishop, 1994, p. 50). This can partly be attributed to Aboriginal culture not valuing mathematics and the formal education system. The traditional Aboriginal learning styles can also affect this. The religious aspects of life were, and still are, transferred through language, including story-telling, singing and ritualised drama. However, most learning of techniques and practical skills was achieved informally through observation and imitation, rather than only language. Many of the processes utilised in daily verbal interaction between Western children and their parents, such as analytical questioning, explaining and discussing, are not commonly found in traditional informal Aboriginal education (Jones et al., 1995, p. 34).

The background of Aboriginal people in relation to mathematics varies considerably from that of many non-

Aboriginal Australians. However, both Aboriginal and non-Aboriginal children are educated in the same school system. Thus it is important to consider the current situation of Aboriginal students in mathematics education. The significance of the present study will now be explained, with previous research results on mathematical performance of Aboriginal students being presented.

Significance

Aboriginal students have a history of failure in mathematics education. In 1995, the Monitoring Standards in Education study found that the mathematics performance of Aboriginal students was 40%, while the overall total performance was 88% for Year Three and 77% for Year Seven students (Malcolm et al., 1999, p. 69). Another study found that the overall performance of Aboriginal students attending mainstream schools throughout Australia (as distinct from those attending Aboriginal schools) was 15-25% below the general Australian population. It was stated that "many of these Aboriginal students in normal schools throughout Australia are not achieving adequate levels of basic literacy and numeracy necessary for what is considered to be a 'normal' life in this country" (Bourke & Keeves, 1977, pp. 153-154). Although this study is quite old, its findings appear to be supported by the results of the Monitoring Standards in Education study, indicating that

little improvement has occurred. Currie, Kissane and Pears (1992, p. 16) stated that "[t]here is a gross under-representation of Aborigines in mathematics classes in the upper secondary school level in Australian schools and Aborigines perform poorly in mathematics compared with non-Aborigines." This apparent lack of success in the mathematical area of education by Aboriginal students is a cause for concern. The result is limited opportunities in employment, as well as ongoing difficulty in those areas of life in which mathematics is required.

It has been established that Aboriginal people have a different background in mathematics, resulting from different requirements and values. The history of the mathematics education of Aboriginal students clearly indicates that there is a need for review and research in this area. Now the literature detailing Aboriginal history in relation to mathematics and mathematical needs, as well as the current situation, will be examined.

Chapter 2

Literature Review

An Aboriginal person is "someone of Aboriginal descent who identifies as such and is recognised by their Aboriginal community to be so" (Horton, 1994, p. 3). The Aboriginal people have inhabited Australia for thousands of years. The Australian climate and environment is harsh and unkind, with extreme temperatures and limited natural resources. The Aboriginal people adapted their lifestyle to accommodate these conditions. They were primarily a hunting and gathering people, who knew how to survive from the land. There was little in the way of material possessions, and dwellings were simple and easily constructed, allowing the people to move and live around the land. Aboriginal people were also a very religious people, with a rich story-telling heritage revolving around the Dreaming. Kinship to other people was very important, and there was a complex system of relationships, and the rules governing them.

This is a traditional picture of Aboriginal people. The modern equivalent covers a wide range of circumstances. There are still some Aboriginal people living in situations not too different from their ancestors. In remote locations, usually in the desert regions of this country, there are communities where the Western way of life has not greatly

influenced the people. They still live off the land in a significant way, although the methods may have changed to include firearms and motor vehicles. The kinship systems and the Dreaming still dictate many of the actions, behaviour and attitudes of Aboriginal people. At the other end of the spectrum are Aboriginal people who appear to be living a Western way of life, such as experienced by the majority of non-Aboriginal Australians. They dwell in cities or towns, are employed in paid work, and take on the many financial and other commitments involved in such a lifestyle. And between these two examples, in countless possible situations, Aboriginal people can be found. However, a common thread seems to run through, regardless of circumstances. Christie observed that "contemporary Aboriginal culture and language retain the crucial distinctive features of Aboriginality" (1985, p. 2). The identification with their Aboriginality and the world view that accompanies it, is present in most Aboriginal people.

World view can be described as "the ideas and beliefs which a group of people hold about its world and the people and things in it" (Christie, 1987, p. 30). The Aboriginal world view has been described as being interactional (Christie, 1985; Harris, 1990). All things are dependent on one another, and interact for common good. Survival depends on co-operation and co-existence with nature, and with other people (Christie, 1985, p. 9). "The Aboriginals concentrate on being, on timeless qualities which unite them to the land

and to other people" (Christie, 1987, p. 32). The focus is on significant qualities in the universe, and on unity and coherence of people, nature, land and time. Time itself is viewed as being cyclic, whereas the Western view of time is linear (Harris, 1990, p. 27). Events which happened long ago are still happening today, and will continue to happen. There is no real distinction between the past and the present. The world view of a group of people both arises from and determines their lifestyle, and this in turn results in the development of certain skills and abilities.

Mathematics can be defined as using "ideas about number, space, measurement and chance, and mathematical ways of representing patterns and relationships, to describe, interpret and reason about their social and physical world" (Curriculum Council, 1998, p. 177). Steen (cited in Curriculum Council, 1998, p. 178) also defined mathematics using ideas about patterns, describing "patterns in number, in space, in science, in computers, and in imagination". Mathematical ideas, and the ways in which they are used, vary between different cultures. "Mathematical knowledge is not empirical knowledge in that its source is not physical reality; rather its source is patterns and relationships created in the mind" (Australian Education Council, 1991, p. 4). Differences in learning and thinking are due to differing patterns of life and cultural demands. The environment in which people live, and the life-style they have developed to accommodate it, determines the

mathematical knowledge and ideas held by those people, and how they use them. The hunting and gathering life-style of the Aboriginal people has resulted in some highly developed abilities in the way they orient themselves in their environment. Dasen (1973) carried out a study on the skills of central Australian Aborigines which had developed in response to their environment. He described the maps drawn on the ground to indicate the location of water-holes. Harris found that Aboriginal people are able to "orient themselves in relation to their environment" and suggested that they had a "mental map" of their surroundings (1980, pp. 11-12). This mental map interpreted the meaning of the landscape, in relation to the Dreaming, rather than simply describing the physical features of the environment. Aboriginal children develop spatial concepts earlier than non-Aboriginal children, and they have been observed responding to a wide spatial vocabulary at an early age (Harris, 1989). In traditional Aboriginal life, daily survival depended on spatial knowledge, and thus it is an important area of learning for Aboriginal people. From an early age, Aboriginal children, particularly those in traditional communities, are taught "the complex, cyclic network of relationships (kinship patterns) which determines and governs their whole life from where they may live and hunt, through to their choice of marriage partner" (Jones, Kershaw & Sparrow, 1995, p. 46). These recursive, systematic kinship patterns give order to Aboriginal life, just as

Western mathematics represents and gives order to Western life. Another area in which an application of mathematics is evident is that of Aboriginal art. Jones et al. discussed the "existence of significant complex, recursive elements in kinship patterns, art, and ceremonial practices" (1995, p. 26). Aboriginal religious beliefs, which permeate every aspect of life, are expressed visually in distinctive artwork, which demonstrates the use of pattern and geometric shapes. In many Aboriginal languages there is a term that means "sing, design, pattern, or meaningful mark" (Sutton, Anderson, Jones, Dussart & Hemming, 1988, p. 3). This term encompasses paintings and other art, but also patterns found in the natural environment, such as honeycomb, spider webs and butterfly wings. Such patterns usually include repetition, variation and symmetry, and are recreated in Aboriginal artwork. Aboriginal art reflects the relationship with the land, and shapes such as circles and patterns with zigzags are used to convey this meaning.

Thus, it can be seen that there are areas of Aboriginal life in which mathematical ideas and ways of seeing the world have developed. However, there are some aspects of what non-Aboriginal Australians see as mathematics, and what is taught in mathematics education in Australian schools, which are irrelevant and unnecessary to Aboriginal people. Bain (cited in Christie, 1985, p. 11) commented that "all Western notions of quantity - of more and less, of numbers, mathematics, and positivistic thinking

- are not only quite irrelevant to the Aboriginal world, but contrary to it." Traditionally, Aboriginal people were non-literate and non-numerate, with few material possessions. They had no economy system that required "precise units of quantification" (Knapp, 1981, p. 6), although there was an economy in place. Berndt and Berndt (1992) described six kinds of exchange, for example based on kinship, or to settle grievances or debts. There was no need to precisely measure weight, length, area and volume. Time was perceived in relation to the Dreaming, but the concept of time-telling as known in the Western world was non-existent. Malcolm et al. (1999) observed that Aboriginal people measure time by relating it to events. Malcolm et al. also stated that "in Aboriginal English, quantity in time and space tend to be expressed with non-specific words (drekli, mobs) rather than specific words (hours, minutes, years)" (1999, p. 30). Graham (1986) claimed that Rudder:

> used the term 'qualitative' as opposed to 'quantitative' to describe the way Aboriginal people reflected on their world. He claims that this way of classifying the world according to quality extends into the mathematics strand that English speakers refer to as number. (p. 11)

There is research that has supported the view that Aboriginal languages do not have number systems that go much beyond five. Shellshear (1984) claimed that some Aboriginal languages have numbers up to five, and beyond five is usually imprecise. Graham (1987) stated that Aboriginal terms for numbers are not used for counting, but rather to

indicate the size of a group. Knapp (1981) noted the use of number concepts in the calculation of distance on maps. Aboriginal society is concerned with individuals and small groups of people, as compared to the Western interest in high numbers and calculations. Again, it is the difference between looking at things in terms of quantity or quality. "[P]recision is much more central to western society than in most Aboriginal contexts" (Malcolm et al., 1999, p. 30). "Number words and mathematical terms are developed in each language and culture as the people have a need for them" (Harris, 1989, p. 88). Living in a western society has created more of a need for Aboriginal people to use numbers and the operations that go with them, for example, in shopping, paying bills, running a vehicle and managing an income. However, traditional Aboriginal life did not have such a need. Other research has revealed that, although numbers are unimportant, Aboriginal people possess an intimate knowledge of the characteristics of things. For example, although an Aboriginal stockman would be unaware of the number of beasts, he would know each one by its individual characteristics and thus would know when any went missing (Vaszolyi, 1977). However, Harris (1980) questioned the notion of Aboriginal number systems only counting up to five. Annice and deBerg described this notion as "probably the greatest misconception relevant to the teaching of mathematics" (1986, p. 47). They suggest that some Aboriginal languages have quite sophisticated number

systems, although it varies between languages, and they cite the example of one language with nine different words for the same number. Bishop described body counting "where the number names are synonymous with the name for the part of the body pointed to" (1988, p.24). Gay and Cole (1967) studied the Kpelle people in Liberia, and there are some similarities that can be noted. These indigenous people use similar ways of learning to Australian Aboriginal people. It was observed that they too have a number system, but use it differently to what was presented in the schools. For example, there are certain restrictions on what can be counted, as it will bring bad luck to count domestic animals. The Kpelle people don't often count beyond thirty or forty, as it is not often required of them in their daily activities. However, their number system does enable one to go beyond this if they need to. As in the case of the Aboriginal Australians, need dictates what and how much is counted, but the culture itself emphasises individuals and small groups. Dame Mary Gilmore documented counting skills of Aboriginal people in New South Wales (Aboriginal Perspectives, 1996, 6.2). From her own personal childhood experiences, she recalled Aboriginal stockmen being known for their accuracy and speed in counting cattle, and Aboriginal children counting stars through grouping and pattern. This suggests that the concepts of a number system do exist, even if there are no specific words in Aboriginal languages for them. The absence of words may indicate both

social insignificance and the lack of need to use numbers.

Language plays an essential role in education. However, language is often a barrier for Aboriginal children, particularly for those for whom English is a second language. "A language linguistically remote from English does not simply express mathematical ideas in a very different way: it may not express some of them at all, because those ideas may not be the ideas of the speakers of that language" (Harris, 1989, p.86). Kepert found that students who use English more at home seem to have developed a world view compatible with school mathematics (1991, p. 32). However, Aboriginal children, even those who speak English at home, "are still being socialised in Aboriginal society where concepts and numerical terms are more poorly developed than in non-Aboriginal society" (Shellshear, 1984, p. 161). Malcolm et al. described the version of English used by many Aboriginal people as "Aboriginal English" (1999, p. 2). Aboriginal English is governed by rules, and differs from Standard Australian English in pronunciation, expressions, grammar and choice of words. Aboriginal English, like any other language, "shows, by the ways in which it lends itself to the expression of certain meanings in certain ways, what [Aboriginal people] as a group value in common" (Malcolm et al., 1999, p. 3). Concepts are only identified in a language if they are important to the speakers of that language. As stated earlier, quantity is less important to Aboriginal people than quality. Malcolm et

al found that speakers of Aboriginal English tend to equate extent with excess, using the term "too many" or "too much" to indicate "lots" or "very" (1999, p. 31). If the concepts of measuring and quantifying are irrelevant or viewed differently, then the language may not allow for the discussion of them. It is not simply a matter of translation of terms. Many of the underlying concepts involved in mathematics, particularly numeracy, are unknown, and often contrary to the Aboriginal way of thinking.

Studies in education in Australia show that the performance of Aboriginal children in mathematics is lower than that of non-Aboriginal children (Bourke & Keeves, 1977; Malcolm et al., 1999). Results from the Monitoring Standards in Education testing carried out in 1995 revealed that the mathematics performance of Aboriginal students in years 3, 7 and 10, was assessed at 40%, compared with the overall totals of between 77% and 88% (Malcolm et al., 1999, p. 69). Bourke and Keeves (1977) separated Aboriginal students into two groups, those attending Aboriginal schools in the Northern Territory, and those attending other schools across Australia, both metropolitan and non-metropolitan. For the purposes of this study, the second group is of interest. It was found that "14 year old students in group 2 performed almost as well as all Australian students on [items on recalling number facts]" (Bourke & Keeves, 1977, p. 146). However, overall the performance of this group of students, at ages 10 and 14, was assessed as being 15-25% below that

of all Australian students. "Whatever the reasons are, many of these Aboriginal students ... are not achieving adequate levels of basic literacy and numeracy necessary for what is considered to be a 'normal' life in this country" (Bourke & Keeves, 1977, pp. 153-154).

The present study is being undertaken in order to investigate the number sense, or the understanding about numbers, of urban Aboriginal primary children. The Number Sense Test developed by McIntosh, Reys, Reys, Bana and Farrell (1997) aimed to assess how well students understood the processes of numerical operations and their ability to communicate and interpret such understanding. The Number Sense Test has been selected for the present study as its focus is on understanding and the effective use of quantitative methods. The literature reveals that Aboriginal people living in a traditional style have had little use in the past for the numerical aspects of mathematics. The present study is investigating the extent to which urban Aboriginal primary students have been influenced by this history.

Chapter 3

Research Design

Aim

The aim of this research is to assess the number sense of urban Aboriginal primary students using the Number Sense Test, and to compare the results to those of Australian students tested in a previous study.

Research Question

Is the number sense of urban Aboriginal primary students significantly different from that of urban non-Aboriginal primary students ?

There are some terms which will be referred to which will now be defined. The titles given to the sample groups are used for identification and for distinguishing between the groups.

Operational Definitions

McIntosh, Reys, Reys, Bana and Farrell define number sense as "[a] propensity for and an ability to use numbers and quantitative methods as a means of communicating, processing and interpreting information" (1997, p. 61). It involves an intuitive understanding about numbers and how to use them in practical ways.

An Aboriginal person is "someone of Aboriginal descent who identifies as such and is recognised by their Aboriginal community to be so" (Horton, 1994, p. 3).

The Aboriginal sample group refers to the Aboriginal subjects tested in this study.

The Non-Aboriginal sample group refers to the subjects tested in this study who are not Aboriginal. This group contains subjects of various cultural backgrounds.

The Australian sample group refers to the Australian subjects tested in the Number Sense study by McIntosh, Reys, Reys, Bana and Farrell (1997). There is no information on the cultural backgrounds of the subjects within this group.

The Number Sense Study will refer to the study carried out by McIntosh et al. (1997). It is this study which provides the basis and comparison for the present study.

Design

The Number Sense Test has been selected to assess the number sense of the subjects in this study. The test is supported by interviews with selected subjects. The interviews allow the thought patterns and general understandings of the subjects to be more accurately assessed, as the subjects are asked to explain how they arrived at their answers.

It is difficult to assess such a thing as number sense through a short answer written test, even with the addition of the interviews. However, there are several reasons for using the test. Firstly, it is a reasonably efficient and economical way of testing the number sense of the subjects. In a small research project, time and resources are limited. Thus, the use of the test enables some results to be gathered within the parameters of a research project of this size. The second reason for using the Number Sense Test is that the previous study by McIntosh, Reys, Reys, Bana and Farrell (1997) provides a ready control group, useful for purposes of comparison. There are some difficulties with using the results of McIntosh et al. (1997). However, these will be explained later. Finally, using a written test alleviates the problem of human interpretation distorting the results. The answers are simple to mark, providing statistical data which can then be analysed and compared to that of the Number Sense Study.

Chapter 4

Methodology

Target Population

The subjects in this study are Aboriginal and non-Aboriginal students attending a public primary school in metropolitan Perth. The Number Sense Study selected mid-sized to large schools located in districts near a university. However, due to the distribution of Aboriginal people in Perth, the scope and size of this study and access into a school, the subjects were selected from a school with a significant number of Aboriginal students. The three age groups tested include the school years 3, 5 and 7, or approximately 8, 10 and 12 years of age. Five Aboriginal and five non-Aboriginal students in each age group were tested. In the year 5 group, only 4 Aboriginal subjects completed the test. The Number Sense Study tested approximately 180 students in each age group. 3% of the population in Western Australia is Aboriginal (McLennan, 1997, p. 12). The same proportions are used, that is, 3% of the 180 subjects in the Number Sense Study is close to 5. Availability of subjects also influenced the number of subjects in each group.

The non-Aboriginal students were included to increase

the validity of the test when comparing the results to those of the Australian students in the Number Sense Study. Although this study is concerned with Aboriginality, it needs to be noted that a number of subjects from the Non-Aboriginal sample group are of Vietnamese origin. This includes two of the Year 3, four of the Year 5 and one of the Year 7 subjects. All of these subjects were born in Vietnam, and have lived in Australia for between four and nine years.

Instruments

The researchers in the Number Sense Study developed a number sense framework, based on literature about number sense, estimation and mental computation. This framework is outlined in Appendix A. Test items were developed from this framework. The items were tested in interviews in USA. Those which "evoked thoughtful introspection (rather than immediate recall of a rule or known fact) and relied on conceptual understanding" were kept (McIntosh, Reys, Reys, Bana & Farrell, 1997, p. 9). In total, 101 items were kept. Each test contains a selection of items appropriate to the age level. The tests for 8, 10 and 12 year olds contain 30, 35 and 45 items respectively. Appendix B lists the test items and indicates the corresponding question number in each of the tests. A sample from the Year 3 test paper can

be seen in Appendix C.

The interviews consist of ten items selected from the written tests (Appendix D). These items are presented in the same format as the Number Sense Test. The ten items were selected so that each of the first five strands of the Number Sense Framework (Appendix A) are represented.

Procedure

The tests were administered during class time on Monday mornings early in Term 3 of the school year. The location was the Aboriginal homework centre, a classroom in which the school's Aboriginal students attend homework classes.

The subjects were each provided with a pencil. The test papers were handed out and the subjects asked to write in their names. The items were read aloud, in order to eliminate any bias due to reading difficulties. Once the item was read aloud, the subjects were given thirty seconds in which to write their answer on the test sheet. No other writing was permitted. After the allocated time, the next question was read aloud. Subjects completed two practice items in the same format as the test, before commencing the test. The test administration protocol was very similar to that used in the Number Sense Study.

The interviews occurred two weeks after the written tests. Two Aboriginal subjects and two non-Aboriginal

subjects were selected from each year level for the interviews. In the Year 5 Aboriginal sample group only one subject was available for an interview. The tests were scored prior to the interviews. As far as possible, the two subjects interviewed from each sample group were those who had achieved the highest and lowest scores for their group. The subjects were interviewed one at a time. The subjects were given thirty seconds to complete each item. They were then asked to explain how they arrived at their answer. Further questions were asked in order to clarify the verbal responses and get a clear insight into their thought processes.

Chapter 5

Data Analysis

The data were analysed using the *t* test, at a significance level of 0.01.

Results

The test items were scored as correct or incorrect. Each subject received a score representing the number of items answered correctly. The individual scores for the Number Sense Test are shown in Table 1. The maximum possible score, that is the total number of test items, for each age group is shown in brackets in the first column.

Table 1

Number Sense Test Raw Scores

	Aboriginal subjects	Non-Aboriginal subjects
Year 3 (30)	2, 3, 3, 5, 6	4, 5, 6, 7, 11
Year 5 (35)	6, 7, 9, 10	5, 6, 7, 15, 17
Year 7 (45)	5, 10, 19, 21, 25	11, 13, 16, 18, 32

Only four scores are listed for the Year 5 Aboriginal subject group. Although five subjects were present, one

subject refused to participate and left before the test commenced.

Table 2 summarises the results of the Number Sense test for each sample group in this study. N refers to the number of subjects in each sample group. SD is the standard deviation for each set of data.

Table 2

Summary of Number Sense Test Results

	N	Maximum possible score	Range	Mean	SD	Standard error
Aboriginal Year 3	5	30	2-6	3.8	1.6	0.7
Non-Aboriginal Year 3	5	30	4-11	6.6	2.7	1.2
Aboriginal Year 5	4	35	6-10	8	1.8	0.9
Non-Aboriginal Year 5	5	35	5-17	10	5.6	2.5
Aboriginal Year 7	5	45	5-25	16	8.2	3.7
Non-Aboriginal Year 7	5	45	11-32	18	8.3	3.7

Table 3 shows the results for the Australian sample group from the Number Sense Study. The data are presented in the same format as Table 2 to allow for comparison.

Table 3

Number Sense Test Results for Australian Sample

	N	Maximum possible score	Range	Mean	SD	Standard error
Year 3	180	30	3-30	15.4	5.1	0.4
Year 5	167	35	8-30	18.4	5.1	0.4
Year 7	168	45	5-44	23.6	7.7	0.6

When the results from Tables 2 and 3 are compared, the following points can be noted.

Year 3.

None of the Year 3 subjects tested in this study achieved the mean score of the Australian sample. The highest score was 11, compared with the Australian sample mean of 15.4. Three subjects from the Aboriginal sample group scored equal to or lower than the lowest score in the Australian sample group. There are significant differences between the scores for all three sample groups. The Aboriginal sample group scored significantly lower than the

Non-Aboriginal sample group. The Non-Aboriginal sample group scored significantly lower than the Australian sample group.

Year 5.

None of the subjects tested in either of the Year 5 sample groups in this study achieved the mean score of the Australian sample group. The highest score in the Aboriginal group was 10. The highest score in the Non-Aboriginal group was 17. The Australian sample mean score was 18.4. Five subjects scored lower than the lowest score from the Australian sample group. Two of these subjects were Aboriginal and three were Non-Aboriginal. Only four scores were recorded for the Aboriginal sample group in this age group. There are no significant differences between the Aboriginal and Non-Aboriginal Year 5 sample groups. Both of these groups showed a significant difference from the Australian sample group. The scores of the Aboriginal and Non-Aboriginal sample groups are significantly lower than the scores of the Australian sample group.

Year 7.

Two Year 7 subjects, one Aboriginal and one Non-Aboriginal, scored higher than the mean score of 23.6 of the Australian sample group. One subject from the Aboriginal sample group scored the same as the lowest score

from the Australian sample group. The means of the Aboriginal and Non-Aboriginal sample groups are similar, as are the standard deviations. The two groups have the same standard error. There are no significant differences between the Aboriginal and Non-Aboriginal sample groups. The Australian sample group scored significantly higher than both the Aboriginal and Non-Aboriginal groups.

The data from the test results were analysed in several different ways in order to reveal as much as possible about the Number Sense of the subjects. These will be discussed next.

Number Type.

The test items were analysed according to the type of number represented, that is whole numbers, fractions, decimals and percentages. Table 4 shows the mean percentages of correct responses for each sample group on the Number Sense Test according to number type. The table indicates the number types tested at each age level.

Table 4

Mean Percentages by Number Type

	Whole number	Fractions	Decimals	Percentage
Year 3				
Aboriginal	11	17		
Non-Aborig	25	11		
Australian	49	60		
Year 5				
Aboriginal	28	32	8	
Non-Aborig	34	26	22	
Australian	55	57	48	
Year 7				
Aboriginal	35	23	44	70
Non-Aborig	50	28	39	70
Australian	59	42	54	84

Some of the figures for mean percentages appear deceptive. Statistical analysis showed no significant difference between whole number and fraction items for both the Aboriginal and the Non-Aboriginal sample groups in Year 3. The Year 3 Australian sample group scored significantly higher on fractions than on whole number items. There is a significant difference in the mean percentages of the Year 3 Aboriginal and Non-Aboriginal groups for whole number

items. The Australian sample group scored significantly higher than the other sample groups in both whole number and fraction items.

At the Year 5 level, more differences started to emerge. Between the Aboriginal and Non-Aboriginal groups, only decimal items showed a significant difference in performance. The Aboriginal sample group performed better on items relating to whole numbers and fractions, than they did on items relating to decimals. Whole number items are significantly better than decimals and fractions for the Non-Aboriginal sample group. The Australian sample group scored significantly higher than both the Aboriginal and Non-Aboriginal sample groups in all areas.

There are significant differences between the mean percentages of all the items for the Year 7 Non-Aboriginal sample group. The Aboriginal sample group showed no significant difference between decimals and percentages. All other differences between items according to number type are significant for the Aboriginal sample group. The Australian sample group recorded significant differences between the performance on all number types, except between decimal and whole number items. When comparing the performances of the Aboriginal and Non-Aboriginal groups, only items relating to whole number showed a significant difference. The Australian sample group scored significantly higher than both the Aboriginal and Non-Aboriginal sample groups on items relating to whole number,

fractions and decimals.

Number Sense Strands.

Another way of looking at the test items is according to the number sense strand they represent. The number sense strands are outlined in Appendix A. Table 5 shows the mean percentages of correct answers according to the Number Sense strands represented by each item.

Table 5

Mean Percentages by Number Sense Strands

	Number concepts	Multiple represen-tations	Effect of operations	Equivalent expression	Computa-tion and counting strategies
Year 3					
Aborig.	3	15	10	20	27
Non-Abl	23	20	15	45	10
Aust.	54	58	35	53	54
Year 5					
Aborig.	14	16	25	42	25
Non-Abl	20	20	29	50	31
Aust.	55	57	37	74	46
Year 7					
Aborig.	34	40	37	31	34
Non-Abl	36	31	52	46	34
Aust.	54	57	50	53	54

There are no significant differences in the scores of the Year 3 Australian sample group between the number strands. The Year 3 Aboriginal sample group scored significantly lower on number concepts than on three other strands. The Year 3 Non-Aboriginal sample group scored

significantly higher on equivalent expressions than on three other strands, and significantly lower on computation and counting strategies than on two other strands. The Aboriginal subjects in Year 3 scored significantly lower on number concepts than the Non-Aboriginal group. The Australian sample group scored significantly higher than both the Aboriginal and Non-Aboriginal groups on number concepts, as well as multiple representations, and computation and counting strategies. The Aboriginal sample group's highest score was on computation and counting strategies, which was the strand for which the Non-Aboriginal group scored the lowest percentage. However, no significant difference can be detected between the scores of the two groups. There are no significant differences between the three sample groups on effect of operations items. The Australian group performed significantly better than the Aboriginal group on items relating to equivalent expressions.

In Year 5 all three sample groups scored their highest percentages on items from the strand of equivalent expressions. The Australian and Non-Aboriginal groups scored significantly higher on this strand than on all the other strands. For the Aboriginal group, this strand was significantly higher than number concepts and multiple representations. The Australian sample group scored significantly lower on the effect of operations strand than on three other strands. No significant difference exists

between the Aboriginal sample group and the Non-Aboriginal sample group for each number sense strand. The Australian sample group scored significantly higher than the Aboriginal sample group on all number sense strands. The Australian group scored significantly higher than the Non-Aboriginal sample group on items relating to number concepts, multiple representations and equivalent expressions.

In Year 7 all three groups scored fairly evenly across the number strands. The only significant difference detected across the number sense strands for any of the groups was the Non-Aboriginal sample group, which performed significantly better than the Aboriginal sample group on items from the effect of operations strand. All number sense strands showed significant differences between the Australian and Aboriginal sample groups. The Australian sample group scored significantly higher than the Non-Aboriginal sample group on number concepts, multiple representations, and computation and counting strategies.

Real-Life Situations.

The test items were also classified according to whether they represented real-life situations, for example involving money or people. Items allocated to the Not Real-life column are those items containing a mathematical expression or problem which are not presented with an example based on a real-life situation. The percentages of correct responses for each group are shown in Table 6.

Table 6

Mean Percentage of Correct Responses to Real-life Items

Group	Real-life items	Not real-life items
Aboriginal Y3	17	9
Non-Aboriginal Y3	16	28
Australian Y3	57	47
Aboriginal Y5	28	21
Non-Aboriginal Y5	27	29
Australian Y5	54	53
Aboriginal Y7	53	32
Non-Aboriginal Y7	50	38
Australian Y7	69	50

All three Aboriginal groups show a higher mean percentage of correct responses to items with real-life examples than to items without real-life examples. These differences are significant for the Years 3 and 7 sample groups. The Non-Aboriginal sample group in Year 7 scored a higher mean percentage on real-life items than on items without real-life examples. However this is not a significant difference. In Years 3 and 5, the Non-Aboriginal sample group performed better on the items without real-life examples. The difference is significant for the Year 3 sample group. The Australian sample groups in Years 3 and 7 performed significantly better on the real-life items. The Australian group scored significantly higher than both Aboriginal and Non-Aboriginal sample groups at all Year levels in both areas.

Interviews.

Two subjects from each sample group, except for one, were interviewed. There was only one subject available from the Year 5 Aboriginal sample group. The following observations were made.

The majority of the subjects seemed to find it difficult to verbalise their thoughts. They appeared to be uncomfortable with the interview situation. The subjects often responded to the questions with comments like, "I just guessed" or "I don't know." This was more common for the Non-Aboriginal subjects than the Aboriginal subjects. One Year 3 Aboriginal subject made the comment, "This is hard." However, this was in relation to being asked to explain how he arrived at each answer, rather than in answering the test items.

The subjects appeared to be hesitant to estimate, for example choosing the answer 'impossible to tell without working it out.' One Year 5 Non-Aboriginal subject said, "I don't know much of my times-tables." This was in response to a test item asking for the best estimate for 29 x 0.98.

The discussion arising from the interviewer's questions led to several answers being changed. This occurred as the subject 'thought aloud' and talked through his or her working processes. This was only demonstrated in the older subjects. A Year 7 Non-Aboriginal subject started to explain an answer, then exclaimed, "Actually, no. That

can't be right, 'cause 4 x 50 is like 200. So I'm going to change that one to 18, because that's bigger than 4."

There were some instances where the subjects gave good explanations of how they arrived at their answers. Item 98 asked how many 10-dollar notes there were in $378. Two Year 7 subjects gave clear explanations of their working out. An Aboriginal subject said, "Because in $100 notes you'd get 10 and 3 you'd get 30, and 7 there is 70, so you'd get... 37." A Non-Aboriginal subject explained, "They won't give you an extra $2.00, so you'll just get 37."

For some of the test items the actual answers were incorrect, but the working out and thought processes were correct. In item 5, subjects were asked to select and place digits in blank spaces in a number sentence in order to arrive at the largest answer. For this item, a Year 3 Aboriginal subject answered 489, rather than 498. She said, "9 is the highest number and that's (8) the second highest." An Aboriginal subject in Year 5 answered item 98 incorrectly, but demonstrated an understanding of place value in his explanation.

In the younger subjects, some unusual reasons for answers were given. Item 17 stated that Sally's grandfather was more than 59 years old and less than 72 years old. Subjects were asked to write three possible ages for the grandfather. During the discussion about Item 17, a Year 3 Aboriginal subject claimed that Sally's grandfather could be 61 years old because "he's very old." The subject then

said that he knew that the grandfather was very old "cause he's got a beard." An item that resulted in some unusual comments being made was item 1, regarding the number of days the subject had lived. Reasons given for ertain answers included, "we live in Australia", "'cause I was born and I kept growing up" and "because it's 2000 and it's going to be a long time to get to 300." There were also some instances of unusual explanations in the older subjects. Item 48 presented a multiplication expression and an addition expression, asking subjects to decide which one represented the larger amount. One subject answered Item 48 on the basis that multiplication resulted in a higher answer than addition. He said, "A has a times and they're all just pluses." However, in general the older subjects gave more reasonable and accurate explanations than the younger subjects.

McIntosh, Reys, Reys, Bana and Farrell defined the 'average' Australian student as being one "whose overall results on the NST placed them in the middle quintile of their age group" (1997, p. 33). If more than 75% of students scored correctly on an item, it was classed as being within the capabilities of a student in that age group. If less than 25% scored correctly on an item, then that item was not within the capabilities of the age group. Using this criteria, McIntosh, et al. (1997) created a profile of an average member of each age group. The same

criteria was used in order to get a profile of the average student in this study. Only Year 5 and 7 students will be discussed, as the Year 3 sample scored low on the NST.

The Year 5 Aboriginal sample group showed that they could;

* select digits from a list to create a fraction close to half
* estimate the number of objects in an area
* compare rates if the relationship is very simple
* indicate an effective strategy for working out the amount of money spent
* understand the relationship between repeated addition and multiplication

At the Year 7 level, the Aboriginal students in this study showed that they could;

* add a simple fraction to a 2-decimal number
* place 0.1 and 0.8 on a number line
* estimate to 1 decimal place a decimal shown on a number line
* compare rates if the relationship is simple
* understand the effect of increasing a number by 50%

Chapter 6

Discussion

There are some differences between the Australian sample group and the Aboriginal and Non-Aboriginal sample groups used in this study. The subjects in the Australian sample group were taken from mid-sized to large schools situated in districts near university campuses. The subjects in the present study attend a metropolitan school which is not situated near a university. The school is located in an area in which a high number of residents rent government-owned dwellings. A similar number of residents are currently paying low mortgages to purchase their own homes. The area has a high rate of unemployment. The concentration of unqualified people in the area means that many employed people live in low income households (Australian Bureau of Statistics, 1993).

There are also language differences between the sample groups. There was no mention in the Number Sense Study regarding the cultural background of subjects. In the present study there are some cultural influences. Seven of the fifteen Non-Aboriginal subjects are Vietnamese. All of these subjects were born in Vietnam and consequently speak English as a second language. They all participate in the ESL (English as a Second Language) program at the school. The Aboriginal subjects also experience language

differences. Aboriginal English is a dialect of English and differs from the Standard Australian English used in schools. There are many differences between the two in words, sounds, rules and usage (Malcolm, 1999, p. 23). Even though students seem to speak English proficiently, they may not understand the way in which the language is used in the classroom for instructional purposes, which can vary considerably from conversational, 'playground' usage. In the Number Sense Test, some of the subjects appeared to experience difficulties in understanding the questions and what was being asked of them. Evidence of this can be seen in test items which subjects tried to answer using basic reading comprehension strategies. The interviews revealed that item 30 was answered in this way, with some subjects deciding that there were 40 apples in each box because the question had stated that.

Language is not the only factor to consider when looking at the impact of the subjects' culture and background. As discussed in an earlier section of this paper, the pre-school years are the time when children are exposed to informal learning in the home. This learning includes learning about the school system, how it works and what is expected of the students within it. Aboriginal children are often at a cultural disadvantage when entering the formal education system as they have not received the same informal education at home. The Vietnamese subjects in this study experience a different culture from that of

either the Aboriginal or the Australian subjects. Although this study is not going to examine the Vietnamese home culture and how it differs from that of other groups, it is acknowledged that a difference is present, and that this difference impacts on the school performance of the subjects.

The time of testing also influenced the results. The testing was carried out on Monday mornings over several weeks early in Term 3 of the school year. There were students arriving late at school, some having gone without breakfast. The school has a high rate of absenteeism on Mondays, often the result of events occurring in the families of the students over the weekend.

Absenteeism results in students missing lessons. Being consistently absent means valuable teaching of new concepts is missed. Students are therefore not being exposed to the same amount of mathematics instruction as those students who regularly attend school, and may entirely miss out on certain topics and concepts. The Number Sense Study was carried out in the second semester of the school year so that the subjects would have covered at least half of the mathematics syllabus content. The present study was also conducted in the second semester. However, consistently absent students would have missed much of the instruction provided, regardless of the time of testing.

One of the greatest limitations of the present study is the number of subjects involved. This was determined by

the size of the study and the availability of subjects. The number of subjects in this study is low when compared to the number in the Number Sense Study. With such a small sample size, any extreme scores affect the data considerably. The sample is not only small, but it is not random. The subjects were those students who were available from the school to which access was granted. Generalisations cannot be made on the basis of such limited data.

Taking into account all of the above factors, there are few conclusions that can be reached as a result of this study. There are too many uncontrolled variables to allow a direct comparison between sample groups to be made. However, the results of the various statistical analyses will now be discussed.

Overall Results

The overall results show that the Aboriginal and Non-Aboriginal sample groups performed significantly lower on the Number Sense Test than the Australian sample groups. This is consistent for all age groups tested. There is no difference between the performance on the Number Sense Test of the Aboriginal students and the Non-Aboriginal students, except at the Year 3 level. The Year 3 subjects all scored low results on the test, and thus differences between the two sample groups are more pronounced. The difference between the highest scores of the Aboriginal and Non-

Aboriginal groups for the Year 3 sample is less than that for the other year levels. However, the low scores resulted in this difference taking on more significance. At the Year 5 and 7 levels, however, it can be assumed that there is no difference between the number sense of the Aboriginal subjects and the Non-Aboriginal subjects in this study. It is interesting to note that the highest scores for each of Non-Aboriginal sample groups were those of Vietnamese subjects. In the context of the overall results, the Non-Aboriginal subjects who are not Vietnamese scored low results on the test. Their performance is no closer than that of the Aboriginal or Vietnamese subjects to that of the Australian sample group. This indicates that the overall performance of all the subjects in this study could be attributed to the social and school environment of the subjects. The Aboriginality of subjects in this study appears to make little or no difference to the performance on the Number Sense Test. Until all variables are consistent, comparisons cannot be accurately made between Aboriginal students and non-Aboriginal Australian students.

The social environment has a great impact on the school performance of children. As stated earlier, the subjects in this study live in an area characterised by low incomes, rental or low mortgage properties, unemployment and lack of educational qualifications. Low parental expectations in regard to education can be the result of such an environment, in which the parents themselves are not

educated at higher levels. That essential informal home learning of many basic concepts such as numbers and counting, colours, and an awareness of the alphabet, can be lacking, putting the students at a disadvantage before they enter the formal education system. The school in this study is attempting to overcome many of the disadvantages of the students. Programs to increase proficiency with English, and the presence in the school of an Aboriginal Education Officer, are two of the ways in which the school is catering for the needs of its students. However, regardless of the extra priorities and needs of the school, the amount of time spent at school is the same for every Australian student. Thus, time spent on remedial and extracurricular activities and programs, although absolutely necessary, has the adverse effect of using valuable school time. Less time is available for the teaching of the mainstream curriculum. Therefore, it can be seen that the background of the students has an enormous impact in many ways on their educational performance and success.

The Number Sense Test was analysed according to several different criteria. These different analyses of the Number Sense Test will now be discussed. As the Year 3 sample groups in this study scored such low results on the test, it is difficult to detect any meaningful patterns. Thus, their results will receive limited attention in the following discussion.

Number Type

In the Year 5 sample groups tested in this study, whole number items showed the highest mean percentage. The test contained more items relating to whole numbers (19) than either fractions (7) or decimals (9). Additionally, in the early years of mathematics education in school, whole numbers receive a greater proportion of instructional time than other areas. This is due to the fact that they could be considered as one of the basic foundation concepts in mathematics.

The Year 7 sample groups all scored their highest mean percentage on items relating to percentages. However, there were only two items in this category, thus limiting the data and any conclusions made as a result of it. All three Year 7 sample groups displayed a weakness in the area of fractions. This is consistent across the three sample groups, which demonstrated similar patterns in performance on the Number Sense Test according to number type. These patterns may reflect the mathematics curriculum and emphases within it on certain aspects of mathematics, rather than revealing any differences between the performance of the sample groups.

Number Sense Strands

The three Year 5 sample groups scored the highest mean percentage on items relating to the Number Sense Strand of

Equivalent Expressions. This strand indicates the ability of the subjects to process information efficiently, by simplifying expressions to a form from which an answer can be derived. Strength in this area indicates effective use of mathematical processes, although an understanding is also essential. It is interesting to note that the Year 5 sample groups in this study produced the weakest results in the area of number concepts. The number concept strand is described as being about "understanding...the meaning and size of numbers" (McIntosh, Reys, Reys, Bana & Farrell, 1997, p. 63) and involves knowing about the base ten number system. This understanding is a vital foundation in mathematics, and a weakness here affects performance in other strands. No differences were detected between the performance of the Aboriginal sample group and the Non-Aboriginal sample group. It will be assumed, then, that differences between the Aboriginal and Australian sample groups are due to the school and social environments of the subjects.

In the Year 7 sample groups, the distribution across the stranαs was fairly even. The Non-Aboriginal sample group displayed a better mean percentage for the strand of Effect of Operations, also scoring significantly higher than the Aboriginal sample group in this strand. There was one subject in the Non-Aboriginal Year 7 sample group who scored much higher results than the other subjects in the group. The higher mean percentage on the Effect of Operations

strand could merely be a reflection of this subject's personal strengths in mathematics. All other mean percentages according to Number Sense strands are evenly distributed.

<u>Items Using Real-Life Examples</u>

This category was formed in order to examine whether any difference existed between the subjects' performance on items which were presented using an example based on real-life situations and items without such an example. These items included those mentioning people (such as items 3, 23, 56), money and shopping situations (items 31, 51, 99), food (items 21, 25, 30) and familiar objects (items 11, 14, 27). The Aboriginal learning style favours real-life situations, and learning skills within these rather than in contrived practice situations. The results of this analysis support this, with all three Aboriginal sample groups displaying a higher mean percentage, significant for Years 3 and 7, on items including a real-life example, than on items without a real-life example. The Australian sample group shows a similar pattern for the Year 3 and 7 sample groups. This could indicate that most children learn more effectively when presented with real-life situations, with which they are familiar. Interestingly, the Non-Aboriginal sample

groups did not reflect the same patterns. The Year 7 group displayed a higher mean percentage for items including real-life examples, but this is not significant. The Year 3 Non-Aboriginal sample group performed significantly better on items without real-life examples. This could be attributed to the cultural background of the Vietnamese subjects, and the influence of their results on the sample groups in which they were included. However, this is not within the parameters of this study and merits more investigation.

Interviews

The interviews indicated that the subjects experienced difficulty with verbalising their thoughts, and had difficulty in explaining how they arrived at their answers. These observations were noted in both Aboriginal and Non-Aboriginal subjects, with no obvious differences between the sample groups. There is no basis for comparison with the Australian subjects in the Number Sense Study, as there was little mention of any interviews conducted. The interviews conducted in the present study were limited and did not reveal as much as they could have. This was partly due to the subjects' reluctance to talk. The researcher feels that the test items were not probed as fully as they should have been. More extensive questioning could have revealed a lot more about each item and the possible reasons for each one being answered as it was.

Chapter 7

Conclusions

This chapter will examine the results of the present study, looking at the conclusions which can be drawn from them. The results will firstly be compared to the results from the Number Sense Study by McIntosh, Reys, Reys, Bana and Farrell (1997), looking at each of the countries which were involved. Then aspects of the present study will be discussed in relation to points which were raised in the literature review (Chapter 2) in order to clarify where the results of the present study reflect and support previous work. It must be remembered that the present study is restricted in size, and therefore the conclusions reached are also limited.

Although the data gathered in this study are limited in size, comparisons were made to the Australian sample group in the Number Sense Study by McIntosh, Reys, Reys, Bana and Farrell (1997). These comparisons showed that both the Aboriginal and Non-Aboriginal sample groups in the present study performed significantly lower than the Australian sample group. The Number Sense Study examined the performance of students in four countries. In addition to Australia, research teams from The United States of America,

Sweden and Taiwan were involved in testing school students in the area of number sense. The Number Sense Study itself was not conducted for the purpose of comparisons between the countries. There were several reasons contributing to this. Due to the way in which the student sample groups were selected (mid-sized to large school district situated close to a university), they were not representative of the school population of each country. In the sample groups from Sweden and Taiwan, the ages of the subjects and the items presented did not match those of the Australian and United States sample groups (McIntosh et al., 1997, p. 33). However, the Number Sense Study did make some comparisons between the countries. It was found that the Australian subjects generally performed better than the United States subjects, with the most marked difference being for the decimal items, but with similar performances on whole number items (McIntosh et al., 1997, p. 15). The performance of the Swedish subjects on the Number Sense Test fell between that of the Australian and United States subjects (McIntosh et al., 1997, p. 43). The test administered to the Taiwanese subjects was too varied in content for any comparisons to be made. However, some interesting observations were made in the discussion of the Taiwanese results. Mathematics education in Taiwan has a strong emphasis on exact answers, and therefore on computational performance. The researchers involved in the Taiwanese aspect of the Number Sense Study constructed a Written Computational Test, the items of which

were presented in a style consistent with the mathematics curriculum. The researchers also constructed a Number Sense Test which contained many of the same items as those used in the Number Sense Tests discussed above. The results from both of the tests administered to the Taiwanese subjects indicated that the subjects were highly skilled in written computation, but that they "lacked understanding of the procedures they were using" (McIntosh et al., 1997, p. 50).

Although comparisons have been made between the performances on the Number Sense Test of the various sample groups and these comparisons are of interest, it can seen that there are restrictions on any conclusions reached as a result of these comparisons. The Australian sample group displayed higher results than the sample groups from both the United States and Sweden. The present study is comparing its results to a fairly high benchmark, although it could be assumed that all the subjects in Australia are receiving the same mathematics education. The performance of the Aboriginal subjects was lower than that of the Australian subjects. However, when it is considered that the performance of the Non-Aboriginal subjects is generally not different from that of the Aboriginal subjects, there is no real basis for attributing the lower performance to the Aboriginality of the subjects. It is interesting to compare the results of the subjects in the present study to the United States subjects from the Number Sense Study. As stated earlier, the performance of the Australian and United

States subjects on items relating to whole number was similar. However, on the other aspects of number type, the United States subjects performed lower than the Australian subjects. When the performance of the United States subjects is compared to that of the Aboriginal and Non-Aboriginal subjects at the Year 7 level in the present study, it can be seen that the United States subjects demonstrated lower performance on items relating to both decimals and percentages, and similar performances on fractions. The overall results on the Number Sense Test of the Year 7 subjects showed the mean of the United States subjects as being 16.7. The mean scores for the Year 7 subjects in the present study were 16 and 18 for the Aboriginal and Non-Aboriginal sample groups respectively. These results were not replicated at the Year 3 and 5 levels. The subjects are participating in different educational systems, which obviously affects any generalisations made. There is also no data available on the cultural background of the United States subjects, as this could also be of interest, particularly the performance of subjects belonging to indigenous groups. However, the comparisons made above can be seen as further evidence to support the view that the number sense of the subjects has little or nothing to do with their Aboriginality, but perhaps can be attributed to environment and educational experiences.

It should also be noted that the results from the Number Sense Study suggest that number sense is directly

related to mental computation skills (McIntosh et al., 1997, p. 54). The amount of instructional time allocated to the development of mental computation skills varies in different classrooms, often as the result of the overall emphasis of each school. Mental computation skills do not feature prominently in most school mathematics assessments, and thus may not receive a significant amount of instructional time. Students who appear to be succeeding at mathematics and who achieve high results on written mathematics assessments may, in fact, be lacking in understanding about what they are doing, due to restricted instruction on mental computational techniques.

The Aboriginal world view has been described as being interactional (Christie, 1985; Harris, 1990). People and nature depend on one another and interact for common good. It is quality rather than quantity that is important. The styles of learning traditionally employed by Aboriginal people were governed by the content of the instruction, for example hunting techniques, art forms and food gathering. The learning styles also reflect the way in which Aboriginal people see the world. Harris described traditional Aboriginal learning styles as being informal, making use of techniques such as learning by observation and imitation, through trial and error, with persistence and repetition, and through real-life performance (1987, p. 42). Some items in the Number Sense Test included examples relating to real-life situations. The results of the Number Sense Test were

analysed according to whether items contained real-life examples. When the percentages of correct answers given for these items were compared with those given for items not containing real-life examples, it was found that the Aboriginal subjects did perform better on items which included real-life examples than on items without real-life examples. This reflects the traditional Aboriginal learning styles, particularly that of learning in real-life situations as opposed to contrived settings. The needs of Aboriginal people living in urban locations are obviously different to the needs of Aboriginal people living in traditional, often remote, communities. There is a greater need to use mathematical skills in daily life, in situations such as shopping, running a car and paying bills. Urban dwelling Aboriginal children are likely to be exposed to many situations in which mathematics is required. They are seeing mathematics being put to work in real life, and the real-life examples given in the Number Sense Test are relevant to them. There are some important implications for mathematics education here. Aboriginal students living in urban locations appear to perform better in mathematics when the examples used in instruction relate to their own real-life experiences. It would make an interesting exercise to replace some of the examples in the items with examples more specific to most Aboriginal people. For example, Item 42 asked subjects to indicate on a square-shaped field where they would be after walking around a third of the field.

This could be made more relevant to Aboriginal subjects by replacing the square-shaped field with a route tracked around trees, water-holes and rocks, while still maintaining the square shape. Item 91, which required the subjects to place a cross on the seventh circle in a row, could be altered by replacing the circles with circular figures used in Aboriginal artwork, or diagrams of animals or native flora. However, as this study has already indicated that Aboriginal subjects perform better when real-life examples are involved, such an exercise would probably confirm these results or indicate a further strength when specific Aboriginal examples are used. The Australian sample group demonstrated similar patterns to the Aboriginal sample group in their results in this analysis, suggesting that most Australian children learn mathematics best when it appears to be relevant and is presented in a form familiar to the children. The results of the Non-Aboriginal sample group in this particular analysis showed a different trend. The Year 3 and 5 Non-Aboriginal sample groups scored higher percentages on the items not containing real-life examples. The cultural influence within these two sample groups may explain these results. Both groups contained more than one Vietnamese subject. The Year 7 Non-Aboriginal sample group, which contained only one Vietnamese subject, showed similar results to the Aboriginal and Australian sample groups. As stated earlier, it is not within the parameters of this study to investigate the number sense of the Vietnamese

subjects. However, it is interesting to observe that the Taiwanese aspect of the Number Sense Study indicated that there was a strong emphasis on computational performance and exact answers within the Taiwanese mathematics curriculum (McIntosh, Reys, Reys, Bana & Farrell, 1997, p.47). An investigation into whether this tendency is present in other Asian countries, such as Vietnam, would be worthwhile. The results in this study indicate that this may be the case.

Harris observed that Aboriginal children develop spatial concepts earlier than non-Aboriginal children (1989). The spatial awareness of Aboriginal people has been found to be highly developed as a result of the requirements of their traditional lifestyle (Dasen, 1973; Harris, 1980). In the Number Sense Test, there were not many items which can be related to spatial awareness, as the test was assessing a different area of mathematics. However, two items are worth examining in this context. Item 4 displayed a box containing many small triangles, and asked subjects to estimate how many triangles were in the box. Answers were presented in a multiple choice format. The Aboriginal sample groups scored higher percentages of correct answers than the Non-Aboriginal and Australian sample groups at the Year 3 and 5 levels. This item was concerned with the size of a group, rather than the counting of individual items. Graham (1987) stated that Aboriginal terms for numbers are not used for counting, but rather to indicate the size of a group. This appears to be reflected in the results of the Year 3

and 5 Aboriginal sample groups on Item 4. The other item to be considered here is Item 42. Here a square-shaped field was presented, and the subjects were asked where they would be after walking around a third of the field. Item 42 was included in the Year 5 and 7 tests. The results of the Year 5 Aboriginal sample group again exceeded those of the other sample groups at the same level. The Aboriginal Year 7 sample group scored similar percentages on this item as the Non-Aboriginal and Australian Year 7 sample groups. Although these are only two items in a test assessing number sense, not spatial awareness, it can be seen that the results on these two items appear to be consistent with the previous work, which suggested a strength in spatial awareness. Other items which also involved some aspect of spatial awareness, such as items 2, 60 and 95, did not provide evidence to be used as support for this view. However, these items also required proficient use of fractions or decimals in order to successfully complete them. Thus, a weakness in mathematical knowledge may have prevented the Aboriginal subjects from demonstrating spatial awareness in these items.

Culture obviously plays an important role in the mathematical orientation of a group of people. As this study has documented, the traditional Aboriginal lifestyle did not require a sophisticated understanding of numbers and the processes that can be done with them. Instead, Aboriginal people developed mathematical abilities in the areas in which they needed them, such as spatial orientation.

Aboriginal artwork also displays an appreciation for and awareness of geometric patterns in nature. For Aboriginal people, relationships with other people and with nature govern their lives. Thus a complex network of relationships has been developed, and is taught to young children. The mathematical areas in which traditional Aboriginal culture seems to be lacking developed skills merely reflect the world view held by Aboriginal people. The Aboriginal view of time is cyclic (Harris, 1990, p. 27), with time being related to events in the past. Thus time-telling is not a required skill. Similarly, the use of a highly developed numerical system was unnecessary for Aboriginal people living in a traditional lifestyle, as there was no need or desire to count large amounts of objects.

It needs to be considered whether the traditional Aboriginal lifestyle has had any effect on the mathematical performance of Aboriginal students living in urban locations. The results of the present study indicate that this could be the case. The Aboriginal subjects did not perform as well on the Number Sense Test as the Australian subjects. However, when the performance of the Non-Aboriginal subjects is also considered, things alter slightly. The fact that the performance on the Number Sense Test of the Non-Aboriginal sample group was generally not different from that of the Aboriginal sample group indicates that there are more factors involved. Performance on the Number Sense Test may have been influenced by factors other

than the Aboriginality of the subjects. As was discussed earlier in this paper, the location of the school is an important variable. The area is characterised by unemployment, unqualified people, low incomes and government housing (Australian Bureau of Statistics, 1993). This can have great impact on the expectations placed on the children with regards to education, as well as determining their experiences in the pre-school years. Additionally, the language of the subjects is another variable which could have affected performance on the Number Sense Test. Subjects who speak English as their second language could face difficulties in interpreting the test items. This is true for many Aboriginal students who speak Aboriginal English as their first language, rather than Standard Australian English (Malcolm, 1999). Other factors like persistent absenteeism from school, along with the time in which the testing was carried out, have all had some influence on the results of the subjects on the Number Sense Test.

The only way in which a true indication of number sense could be gained, would be through a large-scale research project, in which all other variables are controlled. However, there have been some interesting points arising from this study, with implications for mathematics education for Aboriginal students. The main implication is putting into use in classrooms the informal learning styles with which most Aboriginal children are familiar. This would also benefit non-Aboriginal students, as indicated by the

results on the analysis of test results according to the presence of real-life examples in the test items. Presenting mathematics in familiar contexts, supported by examples which are both known and relevant to the students, instantly increases the likelihood of successful learning taking place. More use should be made of shops, cars, sport and the natural environment for introducing new mathematical concepts, with students being given opportunities to observe and imitate, and learn through trial and error where possible. As students become familiar with and capable of using mathematical concepts and ideas, more formal learning styles can be introduced. A recommendation arising from the results of the Number Sense Study by McIntosh, Reys, Reys, Bana and Farrell (1997) is to increase the amount of time spent on mental computation in mathematics classes. It was found that there is a link between number sense and mental computation ability (McIntosh et al., 1997, p. 54). The teaching and practising of techniques for mental computation exercises could, therefore, result in improved mathematics understanding and performance.

It is also important to recognise the mathematical strengths of traditional Aboriginal culture and incorporate these wherever possible. If Aboriginal students see their own culture being portrayed in a positive way, the results could be an increase in self-esteem, and an eagerness to learn. Mathematics could start to become relevant and interesting, and success would be more attainable for the

students. At the same time, teachers must be made aware of the differences in the world view of their Aboriginal students, and how this affects the ways in which they could be interpreting the mathematics education being presented to them. There needs to be extra instruction available in order to provide for the Aboriginal students the background knowledge with which many non-Aboriginal students arrive at school. For example, they need to be immersed in a time-telling environment so that they learn, not only to tell the time, but why such a skill is needed.

Chapter 8

Future Direction

It has been recognised that the results of the present study are limited, due to reasons already discussed. There are some questions which have arisen out of this study, which merit further research. Repeating the study on a larger scale is recommended, so that the problems associated with the small sample size are overcome. However, it is also recommended that there are more attempts made to control other variables, such as the location of the school. There could be a need to test a new Australian sample group, perhaps within several different schools, to ensure that an accurate reflection of the number sense of a typical Australian student is gained.

The presence of Vietnamese subjects in the Non-Aboriginal sample group has brought up the issue of culture in a broader sense. The background of each culture is different, resulting in different ideas and expectations with regards to mathematics education. It was not determined in the present study how the culture of the Vietnamese subjects influenced their results on the Number Sense Test. The presence of so many different cultures in Australian schools at the present suggests that doing further research into how each culture approaches mathematics would be

worthwhile. Examining the mathematical strengths which have developed within each culture, with the view to using these within the classroom, could have benefits for all students. These benefits could result not only in improved mathematical achievement, but also in teaching students to respect and value what other people and cultures can offer.

Finally, the present study was concerned with the performance on the Number Sense Test of urban Aboriginal primary students at one particular school in metropolitan Perth. Much of the previous research which was referred to in this paper has been carried out in communities where Aboriginal people are living in a more traditional style. It would be of great interest to administer the Number Sense Test, and also a mental computation test, to Aboriginal students living in a variety of locations, including remote communities, rural towns and urban areas. A comparison of such results could be very revealing in regards to number sense, and whether the findings of previous research in the area of the mathematics of Aboriginal people are supported.

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Appendix A

Number Sense Framework

This framework is the same as that used by McIntosh, Reys, Reys, Bana and Farrell in their study of number sense (1997, pp.61-67).

Number sense can be separated into three main areas:

1. Knowledge of and facility with NUMBERS
2. Knowledge of and facility with OPERATIONS
3. Applying knowledge of and facility with numbers and operations to COMPUTATIONAL SETTINGS

These are extended into 6 strands:

NUMBERS
1. Understanding of the meaning and size of numbers (Number Concepts)
2. Understanding and use of equivalent forms and representations of numbers (Multiple Representations)

OPERATIONS
3. Understanding the meaning and effect of operations (Effect of Operations)
4. Understanding and use of equivalent expressions (Equivalent Expressions)

COMPUTATIONAL SETTINGS
5. Computing and Counting Strategies
6. Measurement Benchmarks

Appendix B

Number Sense Test Items

This appendix details the test items used in the Number Sense Tests. The terms in the brackets after each item number refer firstly to the number sense strand to which that item belongs, and then the number type used in that item. Y3, Y5 and Y7 refer to the tests for each age level. The numbers next to these indicate the item number in the test for that particular age level. For example, item 1 is the first item in the Year 3 test; the ninth in the Year 5 test; and number 11 in the Year 7 test.
(The item numbers are those used in the Number Sense Study (McIntosh, Reys, Reys, Bana & Farrell, 1997). The total number of items was 101. Some items are not listed here as they were not used in the present study.)

Item 1 (Counting and Computation, Whole Numbers)
Y3 - 1 Y5 - 9 Y7 - 11

About how many days have you lived? (Circle the nearest answer.)	A	300
	B	3000
	C	30 000
	D	300 000

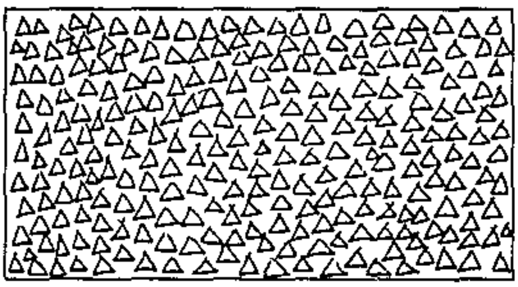
Item 2 (Multiple Representations, Fractions)
Y3 - 2 Y5 - 2

About how much of this box is shaded? Give your answer as a fraction. 	____________

Item 3 (Number Concepts, Fractions)
Y3 - 10

Tom cuts a piece of cake into four equal pieces and eats two of them. What fraction of the whole cake is left?	________________

Item 4 (Counting and Computation)
Y3 - 4 Y5 - 13 Y7 - 22

<u>About</u> how many triangles are there here? (Circle the nearest answer.) 	A 20 B 50 C 100 D 200 E 500

Item 5 (Effect of Operations, Whole Numbers)
Y3 - 5 Y5 - 20 Y7 - 29

The digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Put one digit in each box so that the answer will be as big as possible.	4□□ - 231 = ?

Item 6 (Effect of Operations, Whole Numbers)
Y3 - 6 Y5 - 21 Y7 - 30

Put one digit in each box so that the answer will be as big as possible.	431 - 2□□ = ?

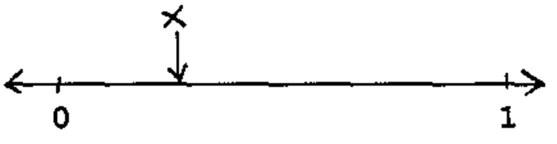
Item 7 (Number Concepts, Whole Numbers)
Y3 - 7 Y5 - 28 Y7 - 34

Here are five digits: **2, 6, 3, 5, 1.** Arrange <u>all</u> these digits to make the smallest number possible.	______________

Item 8 (Number Concepts, Whole Numbers)
Y3 - 8 Y5 - 29 Y7 - 35

Here are five digits: **2, 6, 3, 5, 1.** Arrange them to make the number nearest to 20 000.	______________

Item 10 (Multiple Representations, Fractions)
Y3 - 11

What fraction matches the letter **X** on this number line? (Circle the correct answer.) 	A $\frac{1}{2}$	B $\frac{1}{3}$	C $\frac{1}{4}$	D $\frac{1}{5}$

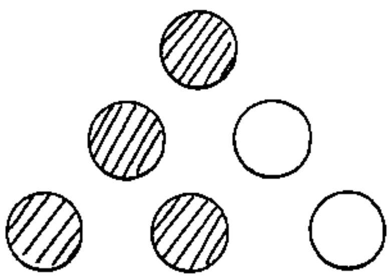
Item 11 (Number Concepts, Whole Numbers)
Y3 - 3 Y5 - 11

The police department is counting the number of cars on a certain highway. The counting meter now reads:

4	7	3	9	9

What will it read after one more car passes by?

Item 13 (Multiple Representations, Fractions)
Y3 - 13 Y5 - 34



Circle the fraction which shows how much has been shaded.

A $\frac{2}{4}$

B $\frac{2}{6}$

C $\frac{4}{6}$

D $\frac{4}{2}$

Item 14 (Number Concepts, Whole Numbers)
Y3 - 14

Circle any piles of shoes which can be put into <u>pairs</u> with no shoes left over.

A 7 shoes

B 34 shoes

C 63 shoes

D 10 shoes

Item 15 (Number Concepts, Whole Numbers)
Y3 - 15

There are ten children in a line at the classroom door. Jenny is sixth in line. How many children are ahead of her?	________________

Item 16 (Number Concepts, Whole Numbers)
Y3 - 16

There are ten children in a line at the classroom door. Peter is fourth in line. How many children are behind him?	________________

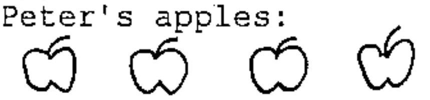
Item 17 (Number Concepts, Whole Numbers)
Y3 - 17

Sally's grandfather is more than 59 years old and less than 72 years old. Write down three different ages he could be.	________ or ________ or ________

Item 20 (Number Concepts, Whole Numbers)
Y3 - 20

When counting, what is the number that comes before 600?	________________

Item 21 (Counting and Computation, Fractions)
Y3 - 21

Peter took half of the apples from a bag. Here are Peter's apples:  Ben took all the others from the bag. How many apples were there in the bag to start with?	____________________

Item 22 (Effect of Operations, Whole Numbers)
Y3 - 22

Five bugs have fifteen spots each. Which of these tells us how many spots there are altogether?	A	5 + 15
	B	15 + 15 + 15 + 15 + 15
	C	15 + 5
	D	5 + 5 + 5 + 5 + 5

Item 23 (Counting and Computation, Whole Numbers)
Y3 - 23

A school has 610 children. If 98 children are away on a trip, <u>about</u> how many are still at school? (Circle your answer.)	A	400
	B	500
	C	600
	D	700

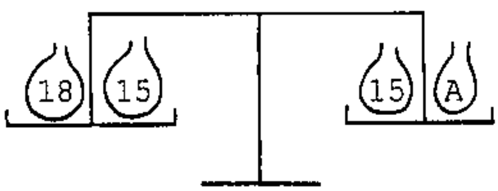
Item 24 (Counting and Computation, Whole Numbers)
Y3 - 24

Whitney has ten dollars. She has six dollars less than Rebecca. How much does Rebecca have?	____________________

Item 25 (Counting and Computation, Fractions)
Y3 - 25

A watermelon is cut into quarters. Then each quarter is cut in half. How many pieces of watermelon are there now? Circle your answer.	A	2
	B	4
	C	6
	D	8

Item 28 (Equivalent Expressions, Whole Numbers)
Y3 - 28



Jim has balanced some bags of marbles. The numbers show how many marbles are in each bag. How many marbles are in the bag marked A? (Circle the correct answer.)	A	3
	B	15
	C	18
	D	33

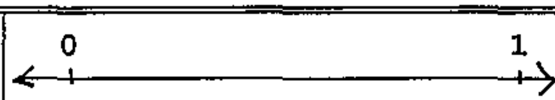
Item 30 (Equivalent Expressions, Whole Numbers)
Y3 - 30 Y5 - 35 Y7 - 43

The farmer has stored all his apples in 80 boxes with 40 apples in each box. He now needs to repack them all into 40 new boxes. How many apples will there be in each new box?	A	2
	B	40
	C	80
	D	120

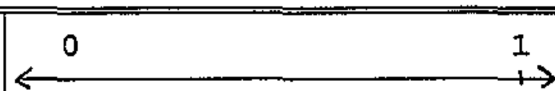
Item 31 (Number Concepts, Decimals)
Y5 - 1 Y7 - 20

For a long time Jane has been putting only 10 cent coins in her piggy bank. Last night she opened it and counted her money. She had $46.70. How many 10 cent coins were in the bank?	________________

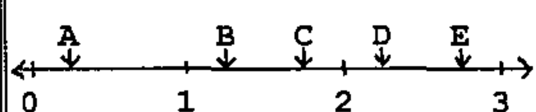
Item 32 (Multiple Representations, Decimals)
Y5 - 3 Y7 - 18

Place the numbers 0.1 and 0.8 in their correct place on this number line:	

Item 33 (Multiple Representations, Fractions)
Y5 - 4 Y7 - 19

Place the numbers $\frac{1}{10}$ and $\frac{4}{5}$ in their correct positions on this number line:	

Item 35 (Multiple Representations, Decimals)
Y5 - 6 Y7 - 2

 Which number on the number line above best represents 2.19?	________________

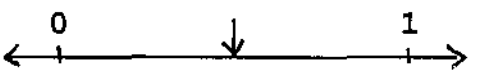
Item 36 (Number Concepts, Fractions)
Y5 - 7 Y7 - 4

Circle the fraction which represents the largest amount:	A $\frac{5}{6}$ B $\frac{5}{7}$ C $\frac{5}{8}$ D $\frac{5}{9}$

Item 38 (Effect of Operations, Decimals)
Y5 - 10 Y7 - 13

<u>Without calculating the exact answer</u>, circle the best estimate for: 29 x 0.98	A more than 29 B less than 29 C impossible to tell without working it out

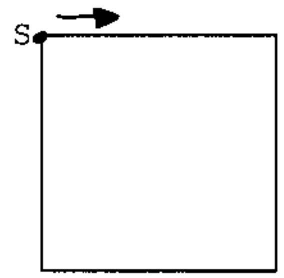
Item 40 (Multiple Representations, Decimals)
Y5 - 14 Y7 - 23

<u>Estimate</u> the <u>decimal</u> shown by the arrow on the number line: 	________________

Item 41 (Multiple Representations, Decimals)
Y5 - 15 Y7 - 24

<u>Estimate</u> the <u>decimal</u> shown by the arrow on the number line: 	________________

Item 42 (Multiple Representations, Fractions)
Y5 - 16 Y7 - 25

You are going to walk once around a square shaped field. You start at the corner marked **S** and move in the direction shown by the arrow. Mark with an **X** where you will be after $\frac{1}{3}$ of your walk.	

Item 43 (Equivalent Expressions, Whole Numbers)
Y5 - 17 Y7 - 26

<u>Without calculating the exact answer</u>, circle the largest product.	A 18 x 17 B 16 x 18 C 17 x 19

Item 46 (Effect of Operations, Whole Numbers)
Y5 - 22 Y7 - 31

When a 3-digit number is added to a 3-digit number the result is:	A always a 3-digit number B always a 4-digit number C always a 5-digit number D either a 3,4 or 5-digit number E either a 3 or 4-digit number

Item 48 (Equivalent Expressions, Whole Numbers)
Y5 - 24 Y7 - 32

Without calculating, circle the expression which represents the larger amount.	A 145 x 4 B 144 + 146 + 148 + 150

Item 50 (Counting and Computation, Whole Numbers)
Y5 - 26 Y7 - 33

Without calculating the exact answer, circle the best estimate for: 18 x 19	A 290 B 390 C 490

Item 51 (Counting and Computation, Decimals)
Y5 - 27

Ten bottles of juice cost $7.95 at one store. I can get 5 bottles for $4.15 at a second store. Where is the juice cheaper - at the first or second store?	A First store B Second store Tell how you decided; ____________________ ____________________

Item 52 (Counting and Computation, Whole Numbers)
Y5 - 30 Y7 - 36

Which two numbers multiplied together give an answer closest to the target number? **4 18 50 37** Target Number **75**	__________ and __________

Item 53 (Counting and Computation, Whole Numbers)
Y5 - 31 Y7 - 37

Which two numbers multiplied together give an answer closest to the target number? **4 18 50 37** Target Number **1000**	________ and ________

Item 54 (Equivalent Expressions, Whole Numbers)
Y3 - 26 Y5 - 32

16 x 0 = ☐ The number in the box...	A ...must be 16 B ...must be 160 C ...must be 0 D ...could be any number

Item 55 (Equivalent Expressions, Whole Numbers)
Y3 - 27 Y5 - 33

15 x ☐ **= 15** The number in the box...	A ...must be 0 B ...must be $\frac{1}{5}$ C ...must be 1 D ...must be 15 E ...could be any number

Item 56 (Number Concepts, Decimals)
Y7 - 1

Scott ran 100 metres in 14.52 seconds. Kelly took 2 tenths of a second longer. How long did it take Kelly to run 100 metres? Circle your answer.	A 34.52 seconds B 16.52 seconds C 14.72 seconds D 14.54 seconds E 14.50 seconds

Item 57 (Number Concepts, Decimals)
Y7 - 3

How many different decimals are there between 1.52 and 1.53? Circle your answer and then fill in the blank.	A None. Why? ____________________ B One. What is it? ____________________ C A few. Give two: ____________________ D Lots. Give two: ____________________

Item 58 (Number Concepts, Fractions)
Y7 - 6

How many different <u>fractions</u> are there between $\frac{2}{5}$ and $\frac{3}{5}$? Circle your answer and then fill in the blanks.	A None. Why? ____________________ B One. What is it? ____________________ C A few. Give two: __________ and __________ D Lots. Give two: __________ and __________

Item 59 (Multiple Representations, Fractions)
Y7 - 7

Circle all the statements that are <u>true</u> about the number $\frac{2}{5}$.	A	It is greater than $\frac{1}{2}$
	B	It is the same as 2.5
	C	It is equivalent to 0.4
	D	It is greater than $\frac{1}{3}$

Item 60 (Multiple Representations, Decimals)
Y7 - 8

Circle the decimal which best represents the amount of the box shaded. 	A	0.018
	B	0.15
	C	0.4
	D	0.801
	E	0.52

Item 61 (Number Concepts, Fractions)
Y7 - 9

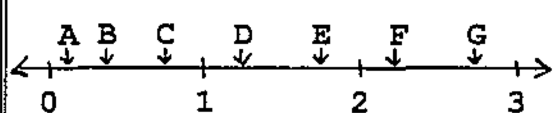
Write a number in the box to make a fraction which represents a number between 2 and 3.	$\frac{\square}{8}$

Item 62 (Equivalent Expressions, Decimals)
Y7 - 10

0.5 x 840 is the same as:	A	840 ÷ 2
	B	5 x 840
	C	5 x 8400
	D	840 ÷ 5
	E	0.50 x 84

Item 63 (Multiple Representations, Fractions)
Y7 - 12

In the fraction $\frac{5}{8}$, 5 is the numerator and 8 is the denominator.	



Which letter in the number line above names a fraction where the numerator is slightly more than the denominator?	____________

Item 64 (Effect of Operations, Decimals)
Y7 - 14

<u>Without calculating the exact answer</u>, circle the best estimate for:	A	a lot less than 87
	B	a little less than 87
87 x 0.09	C	a little more than 87
	D	a lot more than 87

Item 65 (Effect of Operations, Fractions)
Y7 - 15

<u>Without calculating</u>, which total is more than 1? (Circle the correct answer.)	A $\frac{2}{5} + \frac{3}{7}$ B $\frac{1}{2} + \frac{4}{9}$ C $\frac{3}{8} + \frac{2}{11}$ D $\frac{4}{7} + \frac{1}{2}$

Item 66 (Equivalent Expressions, Fractions)
Y7 - 16

Write '*is greater than*', '*is equal to*' or '*is less than*' to make this a true statement:	$5 \times 7\frac{1}{2}$ __________ $35 + \frac{1}{2}$

Item 67 (Effect of Operations, Decimals)
Y7 - 17

<u>Without calculating</u>, decide which one of these answers is reasonable, and circle it:	A 45 x 1.05 = 39.65 B 4.5 x 6.5 = 292.5 C 87 x 1.076 = 93.61 D 589 x 0.95 = 595.45

Item 68 (Equivalent Expressions, Mixed)
Y7 - 39

Circle the number which can be put in <u>both</u> boxes to make this sentence true: **243 x ☐ = ☐ x 24.3**	A 0 B 0.1 C 1 D 10

Item 69 (Equivalent Expressions, Whole Numbers)
Y7 - 40

93 x 134 is equal to 12462. Use this to write the answer to the following: 93 x 135	______________

Item 70 (Counting and Computation, Whole Numbers)
Y7 - 41

93 x 134 is equal to 12462. Use this to find the answer to the following: 12462 ÷ 930	______________

Item 71 (Effect of Operations, Fractions)
Y7 - 42

Circle the number you can put in the box to make this sentence true: $\frac{1}{2} \times \square = \frac{3}{6}$	A $\frac{2}{4}$ B $\frac{2}{3}$ C 1 D 3

Item 72 (Effect of Operations, Percentages)
Y7 - 44

A tank holds 1000 fish. If I increase the number by 50%, how many fish will there be now in the tank? (Circle the correct answer.)	A 500 B 1050 C 1500 D 2000

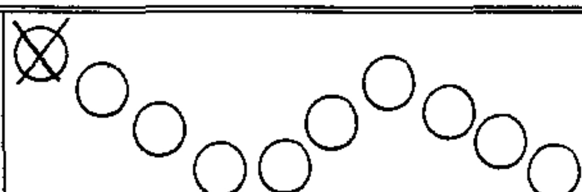
Item 73 (Effect of Operations, Percentages)
Y7 - 45

Dale had $150. She spent 100% of it. How much money did she have left?	A	$0
	B	$50
(Circle the correct answer.)	C	$100
	D	$150
	E	$250
	F	$300

Item 84 (Effect of Operations, Decimals)
Y5 - 19 Y7 - 28

<u>Without calculating the correct answer</u>, circle the best estimate for:	A	less than 29
	B	equal to 29
$29 \div 0.8$	C	greater than 29
	D	impossible to tell without calculating

Item 91 (Number Concepts, Whole Numbers)
Y3 - 12

There is a cross on the first circle. Put a cross on the seventh circle.	

Item 92 (Number Concepts, Whole Numbers)
Y3 - 18

Thirty-four is the same as 34. Four hundred and three is the same as:	____________

Item 93 (Number Concepts, Whole Numbers)
Y3 - 19

Thirty-four is the same as 34. Six thousand and ninety-two is the same as:	____________

Item 94 (Effect of Operations, Whole Numbers)
Y3 - 29

Rustin had $50 and then spends $29. He is given $24 in change. Which sum could he do to check if this is the right change? (Circle the correct answer.)	A 29 + 24 B 24 + 50 C 50 + 24 D 50 + 29

Item 95 (Multiple Representations, Fractions)
Y3 - 9

Shade in three quarters $\left(\frac{3}{4}\right)$ of this shape.	

Item 96 (Number Concepts, Fractions)
Y5 - 5 Y7 - 21

$\frac{3}{4}$ is a fraction between $\frac{1}{2}$ and 1. Name another fraction between $\frac{1}{2}$ and 1.	________________

Item 97 (Counting and Computation, Fractions)
Y5 - 8 Y7 - 5

Put two of the numbers **4, 9, 12** in the boxes to make a fraction as close as possible to $\frac{1}{2}$.	$\frac{\square}{\square}$

Item 98 (Number Concepts, Whole Numbers)
Y5 - 12 Y7 - 38

If I have $378 in my savings account and withdraw all my money, how many 10-dollar notes would the bank be willing to give me?	________________

Item 99 (Effect of Operations, Decimals)
Y5 - 18 Y7 - 27

Mary had $426 and spent 0.9 of it on clothes. <u>Without calculating the exact answer</u>, circle the best estimate for how much she spent.	A slightly less than $426 B much less than $426 C slightly more than $426 D impossible to tell without calculating

Item 100 (Equivalent Expressions, Whole Numbers)
Y5 - 23

Jim bought 3 sleeping bags at $98 each. How could he work out how much he spent? (Circle the correct answer.)	A 3 lots of $100, take $1 B 3 lots of $100, take $2 C 3 lots of $100, take $3 D 3 lots of $100, take $6

Item 101 (Effect of Operations, Whole Numbers)
Y5 - 25

Without calculating the exact answer, circle the best estimate for: 45 x 105	A 4000 B 4600 C 5200

Appendix C

Sample from Year 3 Number Sense Test

Name : ______________________________

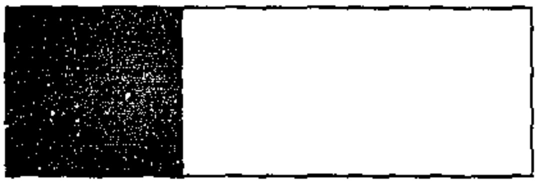
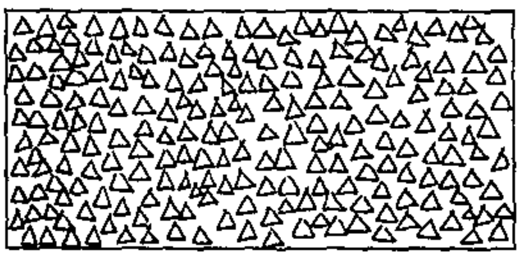
Practice Questions:

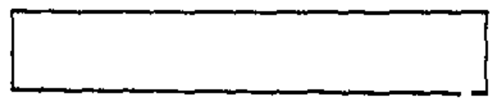
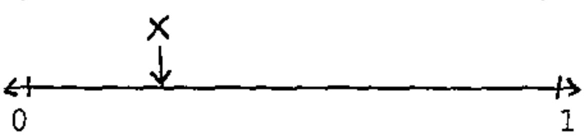
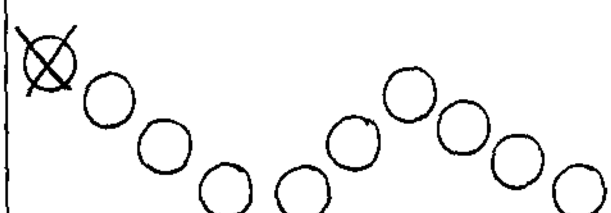
1. Without counting exactly, about how many children are there in your class? (Circle the nearest answer.)	A 3 B 30 C 300 D 3000
2. What number goes in the box to make this sentence true? **30 + ☐ = 50**	--------------

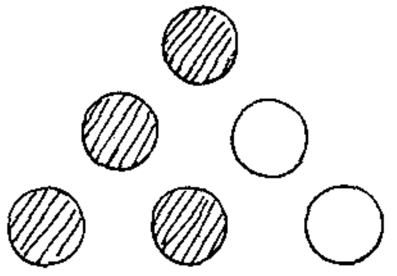
DO NOT turn over the page until you are told.

DO NOT write anything except your answer.

You will have 30 seconds for each question.

QUESTION	ANSWER
1. About how many days have you lived? (Circle the nearest answer.)	A 300 B 3000 C 30 000 D 300 000
2. <u>About</u> how much of this box is shaded? Give your answer as a <u>fraction</u>. 	______________
3. The police department is counting the number of cars on a certain highway. The counting meter now reads : | 4 | 7 | 3 | 9 | 9 | What will it read after one more car passes by?	[ ] [ ] [ ] [ ] [ ]
4. <u>About</u> how many triangles are there here? (Circle the nearest answer.) 	A 20 B 50 C 100 D 200 E 500
5. The digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Put one digit in each box so that the answer will be as big as possible.	4 [ ] [ ] - 231 = ?

6. Put one digit in each box so that the answer will be as big as possible.	431 - 2☐☐ = ?
7. Here are five digits: **2, 6, 3, 5, 1.** Arrange <u>all</u> these digits to make the smallest number possible.	______________________
8. Here are five digits: **2, 6, 3, 5, 1.** Arrange <u>all</u> these digits to make the number nearest to 20 000.	______________________
9. Shade in three quarters $\frac{3}{4}$ of this shape.	
10. Tom cuts a cake into four equal pieces and eats two of them. What fraction of the whole cake is left?	______________________
11. What fraction matches the letter **X** on this number line? (Circle the correct answer.) 	A $\frac{1}{2}$ B $\frac{1}{3}$ C $\frac{1}{4}$ D $\frac{1}{5}$
12. There is a cross on the first circle. Put a cross on the seventh circle.	

13.  Circle the fraction which shows how much has been shaded.	A $\frac{2}{4}$ B $\frac{2}{6}$ C $\frac{4}{6}$ D $\frac{4}{2}$

Appendix D

Test Items Presented in Interviews

Year level	Item number	Number sense strand
Year 3	7	Number concepts
	17	Number concepts
	10	Multiple representations
	13	Multiple representations
	5	Effect of Operations
	94	Effect of Operations
	30	Equivalent expressions
	54	Equivalent expressions
	1	Counting and computation
	4	Counting and computation
Year 5	7	Number concepts
	98	Number concepts
	13	Multiple representations
	42	Multiple representations
	6	Effect of Operations
	38	Effect of Operations
	30	Equivalent expressions
	48	Equivalent expressions
	1	Counting and computation
	53	Counting and computation
Year 7	7	Number concepts
	98	Number concepts
	42	Multiple representations
	63	Multiple representations
	5	Effect of Operations
	46	Effect of Operations
	30	Equivalent expressions
	43	Equivalent expressions
	1	Counting and computation
	53	Counting and computation