THE MODALITY FACTOR IN TWO APPROACHES OF ABACUS-BASED CALCULATION AND ITS EFFECTS ON MENTAL ARITHMETIC AND SCHOOL MATHEMATICS ACHIEVEMENTS

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2007

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by

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Thesis submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy

February 2007

AKNOWLEDGEMENT

Very special thanks to my Supervisor, Assoc. Prof. Loo Seng Piew for his extraordinary patience in enduring with me for almost 10 years during my tenure as his Ph.D. student. His guidance and supervision throughout this period was precious and without his inputs it would have been impossible to complete this arduous task. Not forgetting also my co-supervisors, Prof. Ng Wai Kong and Dr. Ong Saw Lan for their ever caring and professional consultation in my time of need and confusion, I would like to say a big thank you to them. To the Dean of the School of Education, lecturers and supporting staff who were ever willing and helpful in helping me, I would also wish to record my appreciation and thanks.

I would like to thank Assoc. Prof. Dato' Jamaluddin Mohaiadin, Deputy Vice Chancellor Student Affairs and Development Division and former Director of the Centre for Instructional Technology & Multimedia and Assoc. Prof. Toh Seong Chong (Centre for Instructional Technology & Multimedia) for allowing me to audit their courses at the initial part of my studies. The latter has also been very helpful in guiding me in the selection of appropriate instruments especially in dealing with young children. Not forgetting also the Chinese abacus expert, Prof. Xu Sizhong who has been very helpful in providing valuable books and materials for this research.

Besides that, various people had been very accommodating and helpful in providing me the necessary assistance and opportunity in carrying out the research in the field. They were headmasters and headmistresses of the schools involved, the Director of Education of Penang State and also my College Director. The headmaster of SK Penanti, En. Mustapha had been especially kind in responding to my request after my earlier failure in getting schools to get involved in the study. Not forgetting also Headmistress Pn. Radiah from SK Seri Impian and Pn. Zaiton from SK Permatang Pasir, Headmaster En. Che Umar of SK Bukit Indera Muda and their respective Mathematics teachers and pupils involved in this study, special thanks to you all.

To my colleagues and friends who had provided me with valuable criticisms and suggestions in the course of proof reading my modules and thesis, I would also like to record my thanks and appreciation. Both En. Tung from SJK(C) Kim Sin (Master Mathematics Teacher) and En. Lau, Head of Mathematics Department had been helping me to validate the Mental Arithmetic Test and also piloted my module and worksheets prior to the data collection, for this I am very thankful.

To my long suffering wife and children who had been most patient and helpful throughout my studies, I would also like to record my special thanks to them all.

Last but not least, thank you God for making this possible.

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LIST OF ABBREVIATIONS

Abbreviation	Full Term	Equivalent Malay Term
AMA	Abacus Mental Arithmetic	Abakus Aritmetik Mental
CDC	Curriculum Development Center	Pusat Perkembangan Kurikulum
CEFT	Children Embedded Figure Test	Ujian Bentuk Tersembunyi Kanak-kanak
CFIT	Cattell Culture Fair Intelligence Test	Ujian Kecerdasan Bebas Budaya Cattell
ECT	English Competency Test	Ujian Kecekapan Bahasa Inggeris
EPRD	Educational Planning and Research Division	Bahagian Perancangan dan Penyeledikan Pendidikan
ETeMS	English for the Teaching of Mathematics and Science	Pengajaran Matematik dan Sains dalam Bahasa Inggeris
FD	Field Dependent	
FI	Field Independent	
KBSM	Integrated Curriculum for Secondary School	Kurikulum Bersepadu Sekolah Menengah
KBSR	Integrated Curriculum for Primary School	Kurikulum Bersepadu Sekolah Rendah
MAT	Mental Arithmetic Test	Ujian Aritmetik Mental
MOE	Ministry of Education	Kementerian Pelajaran
NCTM	National Councils of Teachers of Mathematics	
PMR	Lower Secondary School Examination	Peperiksaan Menengah Rendah
RME	Real Mathematics Education	
SJK(C)	National Type Chinese Primary School	Sekolah Rendah Jenis Kebangsaan Cina
SJK(T)	National Type Tamil Primary School	Sekolah Rendah Jenis Kebangsaan Tamil
SK	National School	Sekolah Rendah Kebangsaan
SPM	Malaysian Education Certificate	Sijil Pelajaran Malaysia
SPSS	Statistical Packages for Social Sciences	
TIMSS	Third International Mathematics and Science Study	
TIMSS-R	Third International Mathematics and Science Study Repeat	
TED	Teacher Education Division	Bahagian Pendidikan Guru
UPSR	Primary School Achievement Test	Ujian Pencapaian Sekolah Rendah
USM	University Science Malaysia	Universiti Sains Malaysia

FAKTOR MODALITI DALAM DUA PENDEKATAN YANG BERASASKAN PENGIRAAN ABAKUS DAN KESANNYA TERHADAP PENCAPAIAN ARITMETIK MENTAL DAN MATHEMATIK

ABSTRAK

Aritmetik mental dalam bentuk Abakus Aritmetik Mental (AMA), telah muncul semula kepentingannya dalam pembelajaran matematik khususnya untuk kanak-kanak awal di Malaysia. Ia diperkenalkan oleh kerajaan dalam usaha membaiki kelemahan yang sedia ada dalam kurikulum Matematik serta ketidakseimbangan dalam pencapaian matematik mengikut aliran sekolah rendah yang wujud setakat ini. Kajian ini bertujuan mengkaji kesan-kesan pengajaran AMA daripada perspektif teori Dwi Pengekodan dan Beban Kognitif. Faktor modaliti dicadangkan wujud antara dua jenis pengolahan (pendekatan pengajaran) iaitu ***Lisan Dahulu*** *(lisan-abakus, tulisan-abakus dan akhirnya abakus mental) dan* ***Tulisan Dahulu*** *(tulisan-abakus, lisan-abakus dan akhirnya abakus mental) terhadap pencapaian aritmetik mental serta Matematik biasa murid-murid Tahun 1. Ini adalah kerana berdasarkan tinjauan keputusan-keputusan kajian yang berkaitan, kesan modaliti, yang menyebelahi yang pertama, mungkin wujud antara lisan-abakus dan tulisan-abakus. Dengan itu, adalah dicadangkan dengan meletakkan lisan-abakus mendahului tulisan-abakus dalam sesuatu pendekatan tersebut kesan yang sama mungkin wujud. Sampel yang terlibat ialah 199 orang murid Melayu dari tiga buah Sekolah Kebangsaan yang berhampiran yang terletak di kawasan yang sama. Faktor modaliti telah dikesan dengan Lisan Dahulu mengatasi Tulisan Dahulu secara signifikan dalam pencapaian aritmetik mental dan pencapaian Matematik biasa. Secara komponen, komponen Ujian Aritmetik Mental yang ditadbir secara lisan memberi kesan yang sama untuk kedua-dua pengolahan manakala komponen yang ditadbir secara tulisan adalah berbeza secara signifikan dengan Lisan Dahulu mengatasi Tulisan Dahulu. Trend yang serupa juga wujud untuk pencapaian Matematik iaitu tidak berbeza untuk komponen konseptual tetapi berbeza untuk komponen aritmetik. Dengan itu, pengolahan Lisan Dahulu lebih memberi kesan terhadap bahagian aritmetik dalam bentuk tulisan untuk kedua-dua uijan tersebut tetapi tidak memberi kesan yang berbeza untuk bahagian lisan Ujian Aritmetik Mental atau bahagian konseptual Ujian Matematik jika dibandingkan dengan pengolahan Tulisan Dahulu. Di samping itu, ciri-ciri peribadi dari segi kecekapan Bahasa Inggeris, gaya kognitif dan jantina pelajar Tahun 1 juga dibanding di bawah setiap mod pengolahan ini. Kecuali dengan kecekapan Bahasa Inggeris, ciri-ciri ini telah didapati tidak signifikan terhadap pencapaian aritmetik mental. Sebab dan implikasi dapatan ini telah*

dibincangkan berdasarkan perkembangan teori-teori kognitif dan pendidikan matematik sedunia yang terkini.

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ABSTRACT

Mental arithmetic, in the form of Abacus Mental Arithmetic (AMA), has reemerged in its importance to mathematics learning especially for young children in Malaysia. It was introduced by the government in its effort to rectify the present weakness in Mathematics curriculum and also imbalances in its achievements among the three primary school streams. This study aimed to examine the effects of teaching AMA from the perspectives of Dual Coding and Cognitive Load theories. A modality factor was proposed to be present between two modes of treatment (teaching approaches), ***Oral First*** *(oral-abacus, followed by written-abacus and finally mental abacus) and* ***Written First*** *(written-abacus, followed by oral-abacus, and finally mental abacus) on mental arithmetic and school Mathematics achievements of Year 1 pupils. This was because based on reviews on related research findings, modality effect favouring the former, could be present between oral-abacus and written-abacus modes of calculation. Thus it was postulated that by placing oral-abacus first instead of written-abacus in the sequence of teaching approaches above same effect could also be observed. The sample involved was 199 Malay pupils from three neighbouring National Schools in the same vicinity. Modality factor was detected, with the Oral First group significantly outperforming the Written First group for both mental arithmetic and school Mathematics achievements. Component wise, the oral administered part of the Mental Arithmetic Test was the same for both treatments while the written administered counterpart was significantly different with the Oral First group outperforming the Written First group. Similar trend also existed for the Mathematics Test with the effects differed significantly only in the arithmetic component but not the conceptual component. Thus, Oral First treatment had impacted more on the written arithmetic components of both of the tests above but not the oral administered part of Mental Arithmetic Test or conceptual part of Mathematics Test as compared to Written First treatment. Besides that, the personal characteristics of these Year 1 learners such as English competency, cognitive styles (field dependency) and gender were compared under each mode of treatment in mental arithmetic achievement. Save for English competency, the others were found to be not significant. The reasons and implications of these findings were discussed based on the current development in cognitive theories and mathematics education world wide.*

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mental arithmetic literally means solving any mathematical sum or question entirely in the head only (or mentally) without any calculating aids including paper-and-pencil. Mental arithmetic had been popular and commonly taught in schools in the 60s and 70s. However its popularity has declined rapidly due to the emphasis given to written computation (McIntosh, 1998) and the invention and wide usage of calculators, particularly the inexpensive hand held pocket size ones. Nevertheless mental arithmetic is making a come back recently with favor but with modifications (Reys & Nohda, 1994a; Pepper, 1997; McIntosh, 1998). In the West, it has evolved and called mental computation or calculation emphasizing mental strategies for problem solving to distinguish it from the conventional mental arithmetic that usually deals solely with pure arithmetic calculations (Morgan, 1999; Cutler, 2001). In the East, it is coming back in the form of abacus mental arithmetic stressing the usage of mental abacus as an imagery to do mathematical calculation mentally (Hishitani, 1989).

The Malaysian government, particularly under the previous Prime Minister, Tun Dr Mahathir Mohamad, has been a strong advocate in implementing mental arithmetic into the Mathematics curriculum (Lu, 2001) with the aim of raising the standard of the students particularly those from the National and rural schools where the vast majority of the pupils are Malays. However, they chose the latter mentioned method of mental arithmetic that is doing mental calculation with the aid of abacus or more specifically the Chinese abacus or *suanpan* (or *soroban* in Japanese). Locally, it is commonly called *sempoa* in Malay. The rationale for choosing this method of mental arithmetic was that Chinese abacus had been taught in the Malaysian Chinese Primary Schools before and there existed a sizable populace particularly those of Chinese origin who knew how to use the abacus. Hence, it would not be of great difficulty to enroll competent and knowledgeable staff to teach this subject in the schools nationwide (Curriculum Development Centre (CDC), 1999). Furthermore, the use of the abacus in traditional shops and other business establishments is a common sight in Malaysia, even to the non-Chinese. Hence culturally, its introduction into the mathematics classes would not encounter strong resistance in this multi-racial country.

Secondly, comparative studies by Stigler and his associates have consistently revealed that students from the East particularly the Japanese, Korean and Chinese are superior in mathematics achievement compared to their Western counterparts (Stigler & Perry, 1988; Stevenson & Stigler, 1992). Another well-known comparative study is the TIMSS or the Third International Mathematics and Science Study (Jan, 1996). This study revealed that most of the top achievers were from countries in East Asia namely Singapore, Japan, Korea, Taiwan and Hong Kong (China) followed by the Continental European countries such as Hungary and Netherlands where real mathematics is emphasized. The Americans and the British did not fare too well in this comparative study. Similar trend was also observed in the follow up study conducted in 2003 despite the facts that the achievements of these two countries have improved (Mullis *et al*., 2004).

This scenario certainly gives the impression that Eastern superiority in mathematics could be due to the way mathematics is taught in these countries. An outstanding feature that particularly stands out is the usage of abacus in learning mathematics. Thus, once again the abacus – this simple but enduring calculating tool – has caught the attention of the world (Krampner, 1993).

In actual fact, although the Chinese pioneered the use of the abacus, the usage of the abacus was modernized by Japan after the Second World War with strong emphasis on integrating mental arithmetic in abacus or *anzan* computation in Japanese (Shibata, 1994). Later on, the Chinese joined in the reformation of the use of the abacus and developed further the pedagogy of teaching abacus in mathematics classes with the same emphasis on mental calculation as the ultimate goal. The 3-in-1 model that integrates the oral, visual (or written) and mental ways of calculating with the abacus has become popular in China (Hwa, 1987; Xu, 1992). It also means to say that these three modes of abacus-based calculation should be put into practice by the students in any particular lesson of abacus and mental arithmetic (AMA). The recommended sequence as suggested by Xu is oral-abacus, followed by written-abacus and finally mental abacus (abacus imagery). Malaysian primary schools have adopted this method of learning AMA since 2004. Hence the question of whether this particular sequence is also suitable for all Malaysian pupils with varied cultures and languages as compared to the pupils in China may arise. Thus, the main focus of this study is to find out whether this type of sequencing is also suitable for all Malaysian school children particularly the non-Chinese like Malay and if it is not so what will be the best sequence in learning AMA in the Malaysian context.

1.2 Background of the Study

1.2.1 Development of Abacus and Mental Arithmetic Education in Malaysia

Abacus and mental arithmetic have been taught formally and separately from the formal school Mathematics in the Malaysian National Type Chinese Primary Schools (SJK(C)) since independence in 1957. While mental arithmetic was taught from Year 1 to Year 6, abacus, on the other hand, was only introduced from Year 4 to Year 6. Teaching of the two subjects was rigidly regimented with very little variation. Nevertheless, ever since the invention and widespread usage of the hand held pocket size calculators, the popularity of abacus was slowly displaced. Surprisingly mental arithmetic also faded away together with the abacus from the Primary Chinese Schools as the teachers placed greater emphasis on written computation than oral computation.

Similarly, mental arithmetic usually in the form of the oral-chorus manner or commonly called *congak* in Malay has been popular too in the National Primary

Schools (SK). Teachers used to ask arithmetic questions orally to the whole class and the class responded together in a chorus manner. It was not taught as a separate subject as in the Chinese Primary Schools but rather as an integral part of the Mathematics curriculum. This practice however faded away too just as the abacus and mental arithmetic did in the Chinese Schools.

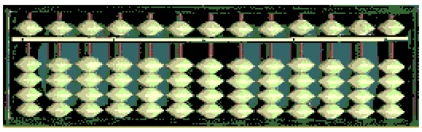
However the awareness of the importance of abacus and mental arithmetic was rekindled once again in the late 80s and early 90s especially after the reports of the First and Second International Comparative Studies of Mathematics Achievement were published (Husen, 1967; Garden, 1987). These studies were conducted by the International Association for the Evaluation of Educational Achievement (IEA). In both studies, the performance of the students from the Eastern countries such as Japan, Korea and Taiwan was found to be consistently higher than the Western counterparts.

This phenomenon has prompted many cross cultural and comparative researches to be conducted between these two blocks of countries notably between the Americans and the Japanese (Reys & Nohda, 1994b). Although there was not a single study that could directly link the use of abacus and mental arithmetic and the Asian superiority in mathematics, many Asians particularly those of the Chinese origin perceived this relationship as the cause of these differences. Once again there was an insurgence of abacus usage all over the world in the late 80s and early 90s of the last century (Xu, 1992). Malaysia was swept by this wave of popularity too. Many private abacus schools such as UC MAS, Aloha and AMI just to name a few with franchise licenses (or joint ventures) originating from mainland China and Taiwan have mushroomed all over Malaysia and other countries in South East Asia like Singapore and Indonesia where there are large populations of localized Chinese. Thus it will not be wrong to say that the private education sector engineered the modern usage of abacus incorporating mental arithmetic in Malaysia.

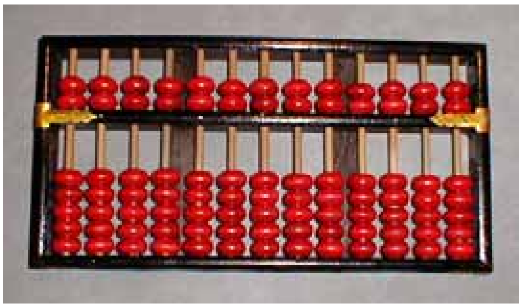
The abacus programmes that have been taught in these private education enterprises are quite different from the abacus programmes that many of the local

Chinese had gone through in the 70s including the researcher himself. These new programmes are commonly called abacus and mental arithmetic programmes implying a combination of abacus and mental manipulation in arithmetic learning. Many of these programmes have been localized, meaning that teaching is done in the native language (Malay) or English and taught by the locals. Besides that, significant changes have been made to its instruction including the use of:

a) the 4-1 format of abacus instead of the traditional 5-2 format (Figure 1.1);
b) smaller and customized size of abacus;
c) new techniques of fingering or moving the beads by the fingers such as using both hands simultaneously;
d) new and simplified versions of rules for the movements of beads during computations.



(a) Abacus with 4-1 format



(b) Abacus with 5-2 format

Figure 1.1: **Different Formats of Chinese Abacus**

These changes are certainly quite different from the abacus curriculum and instruction that were familiar to pupils in the government controlled Chinese Primary Schools (SJK(C)). Furthermore, these new abacus syllabi and techniques are closely related to an important field in mathematics, that is, mental arithmetic. As we all know mental arithmetic has been neglected for a long time (Ewbank, 1977) especially ever since the emphasis is placed on algorithmic mathematics or commonly known as paper-and-pencil mathematics over the oral mathematics (McIntosh, 1998). Similarly there are hardly any Mathematics teachers teaching mental arithmetic nowadays in Malaysian government schools. However, the National Council of the Teachers of Mathematics (or popularly known as NCTM) of America have been strongly advocating its importance in mathematics in which mental arithmetic has been set as one of the NCTM's standards for the guidance of all the schools in America (Schoen & Zweng, 1986).

Many research studies and discussions conducted recently point towards the importance of mental arithmetic especially in the perspective of making estimation while using calculators (Reys & Nohda, 1994a). As we know calculators are easy to use but the calculator has no special feature to prevent errors and carelessness when keying data. As the development of the calculator advances, its usage is going to be increasingly widespread and important especially in the future. Thus teaching pupils or users of calculators to make estimations after keying in (to check answers quickly and alternatively) may seem to be a logical solution to identify and minimize these errors. To estimate, one has to compute mentally and hence mental arithmetic can be the precursor of estimation skills. Therefore, in order to master estimation we need also to master mental arithmetic, that is, to calculate the exact answers mentally (Shigematsu *et al.*, 1994).

In Malaysia these packages of new abacus programmes from the private enterprises have been well received by many including non-Chinese parents. Many Malay and Indian children performed astonishingly well with lightning speed and almost perfect accuracy at various demonstrations and competitions organized by these enterprises (UC MAS, 2001). These excellent performances certainly have caught the eye of the public media, followed by the politicians and educators in top positions in Malaysia. The Minister of Education of the day chose to implement the use of the Abacus and then later added Mental Arithmetic as measures to improve the standard of mathematics in Malaysia particularly to minimize the disparaging difference in mathematics achievement among the various types of primary schools or ethnic groups (Chinese and Malay or Indian pupils) since the enrollment in these schools tend to follow the language and ethnic line (Table 1.1).

Table 1.1 National Mathematics Achievement According to Types of Primary School from 1989 to 2002 (Examination Syndicate, 2002)

	% of Minimum Passes		
Year	**SK/SRK**	**SJK(C)**	**SJK(T)**
1989	75.4	92.6	67.7
1990	57.3	85.1	48.0
1991	60.4	86.6	49.9
1992	60.6	86.8	56.1
1993	63.1	87.6	55.8
1994	64.0	86.3	58.1
1995	67.9	87.6	59.0
1996	74.5	90.0	65.2
1997	75.0	90.2	65.7
1998	77.5	91.2	68.6
1999	76.2	90.0	70.9
2000	75.2	91.2	73.9
2001	76.0	89.9	74.4
2002	82.0	92.6	81.1
AVERAGE	**70.4**	**89.1**	**63.9**

As can be seen from Table 1.1, the SJK(C) (Chinese) consistently emerged as the top performer in national Mathematics achievement from 1989 to 2002 as compared to the SK (Malay) and SJK(T) (Indian). Thus the Curriculum Development Centre (CDC) has been entrusted to study the possibility of including mental abacus in the primary Mathematics curriculum in order to correct these imbalances.

Table 1.2 gives a chronological account of the efforts taken by the Ministry of Education to implement abacus learning formally in the Mathematics curriculum since the early 90s (TTC & CDC, 2001). Many efforts have been taken but they were met

Table 1.2 Implementation of the Abacus Programme by the Ministry of Education (Adapted from Teachers Training Division, TED & CDC, 2001)

Date	Events
Nov 1993	Cabinet approved the use of abacus in school. The School Division was entrusted to implement it.
1994	Ministry of Education (MOE) in corporation with the various State Education Departments started to train Year 4 Mathematics teachers how to use the 5-2 format of abacus. The implementation date was set at 1994/5 session of schooling.
Jan 1995	Monitoring of the Abacus (*Sempoa*) Programme by the School Division in 3 states (Negeri Sembilan, Melaka and Johor).
March 1995	MOE sent a circular informing the schools to change the abacus to 4-1 format instead of the old 5-2 format.
June 1995	First Phase of training about the new format of abacus was given to the Resource Teachers (or key personals). Fast computation (or oral mental computation) was added as part of the Abacus Programme.
Dec 1995	Second phase of training the Resource Teachers.
April 1996	The management of the implementation of the Abacus Programme and Fast Computation was transferred from the School Division to the Curriculum Development Centre (CDC).
June 1996	Suggestions for the implementation of Abacus Education Programme and Fast Computation in schools.
Sept 1996	The involvement of the private enterprise, PM2020 in training 200 Resource Teachers nation wide with consultation from Xu Sizhong.
Feb 1997	200 Resource Teachers were trained in using abacus involving the addition, subtraction, multiplication and division.
1997	Application of extra allocation to expand the training to other teachers. No decision was made.
Oct 1997	Follow-up of Cabinet meeting led to the engagement of TED to implement Mental Arithmetic course to the teachers.
June1998	MOE appointed another private company, UCMAS to train teachers about Mental Arithmetic. TED was given the responsibility to implement it.
March 1999	CDC and TED were asked to coordinate and to straighten out various suggestions for the implementation of abacus and mental arithmetic in schools such that the training of teachers was in accordance with the Guide Book and Teaching and Learning Module in Abacus of the CDC.
Nov 1999	Writing and perfecting of the Training Modules and Guidebook by CDC.
Oct 2001	Training of College lecturers based on the CDC's modules.
2002	Training of 2060 abacus teachers by 23 Teachers Training Colleges throughout Malaysia. Training was conducted in phases.

with little success. In a survey conducted by the Educational Planning and Research Division (EPRD) involving 676 primary schools nation wide in 1999, 7 years after the schools were directed to use abacus in Mathematics teaching, only 12.1% of the schools in the whole country still continue with the teaching at the end of 1999 (Naimah, 2001). Besides that, the study also revealed that 20% of the schools did not even start the abacus teaching at all. Of the schools that still practiced abacus, the percentage breakdown according to types of schools were SJK(C), 24.2%; SK, 10.4%; and SJK(T), 4.2%.

Various factors were given as reasons for the non-compliance with the Ministry directives but the root of the problem was the difficulty in getting enough competent teachers who knew how to use abacus. This reason was cited by the Parliamentary Secretary of the Ministry of Education in Parliament in a reply about the delay of its implementation (Sin Chew Jit Poh, 10 March 2002). According to the Parliamentary Secretary, about 32.7% of the teachers surveyed have not even attended an abacus course before teaching the subject (Naimah, 2001). Thus the real situation or problem was way beyond the Ministry's anticipation.

Many positive steps have been taken by the Ministry to address the said root problem (Table 1.2), notably the engagement of almost all the Teachers Training Colleges (23) in Malaysia to train practicing Mathematics teachers in Abacus Mental Arithmetic (AMA) in 2002. However, this ambitious programme was halted temporarily halfway in its implementation. It was to be continued by another special training programme headed by the CDC and the Chinese consultant (Xu Sizhong) as mentioned earlier. This programme was supposed to be implemented nationwide in 2003 but was delayed and continued in 2004. Untrained local teachers would be trained by local trained lecturers and teachers selected for this programme but under the supervision of this expert and his Chinese team. Those who were trained would in turn start to implement the Abacus Mental Arithmetic (AMA) in schools.

1.2.2 Obstacles and Problems in Implementing AMA

As could be seen from the above descriptions, it was fair to suggest that the curriculum planners have met with various obstacles and failures in carrying out the stipulated plans and objectives primarily because of the lack of knowledge about the abacus. Many educators including those at the top positions still equate these abacus programmes with those that they were familiar with in their childhood days. Even educators of Chinese origin still regarded the abacus as the one that they had been taught to use in their primary school days. Generally they assumed the abacus was just another tool to help students to compute or to calculate mechanically without the use of paper-and-pencil. As such it did not have more advantages as compared to other calculating tool such as hand held calculators. Naimah (2001) reported that teachers from the SJK(C) were generally more negative about the use of abacus than their counterparts from other schools as they cited the use of abacus would not improve the standard of Mathematics achievement as the main factor for not implementing this programme in their schools. A study by Liau and Hong (1994) supported the fact that this negative mindset about the abacus had been so firmly entrenched to the extent that it was difficult to be surmounted. Liau and Hong's study was a survey conducted in Penang involving 124 primary schools of all types in that state. It reported that only 9.0% of the teachers who had attended the course felt that they were ready to use abacus in the teaching and learning process in the classroom while 66.9% were uncertain and 24.1% not ready at all. Surprisingly this pattern of response was similar to that of teachers who had not attended any abacus course, i.e., 4.1% were ready, 75.3% uncertain and 19.9% not ready. Moreover, not a single teacher whether he/she had attended abacus course or not and in all types of primary schools strongly agreed that he/she was ready to use the abacus in the class.

Ever since the reformation of abacus learning in Japan and China, many new developments and changes have taken place about the teaching and learning of the subject. Thus it was fair to suggest that many educators including those in the top positions and trainers of the abacus course were less aware of these changes and development. Hence they were not able to change the attitude and mindset of the teachers who had attended the abacus course as they themselves were not convinced too of the importance of abacus in the teaching of mathematics. This could also be the cause for the change from the 5-2 format to the more modern 4-1 format of abacus halfway through the implementation in 1995 which resulted in making many abacus of the old format been left idle in the schools after 1995. This decision might imply that those decision-makers themselves were lacking in the knowledge about the recent advancement in abacus. Besides that, this hasty decision coupled by the Ministry indecisiveness about the course of action to be taken about this programme had caused teachers to lose confidence about this programme especially those teachers from the SK and SJK(T) (Naimah, 2001). Let us discuss this problem further.

At the beginning stage of its implementation, the School Division officials had engaged many local Chinese teachers and lecturers to plan and to write the new curriculum and training modules for this programme (School Division, 1994). They were also responsible for carrying out training sessions for the Resource Teachers (trainers) of various states. These Resource Teachers in turn would become the trainers to train other teachers in their respective states. However this master plan seemed to be too simple to be effective and as such the plan seemed not to work although most of the National Primary Schools nationwide had been supplied with the abacus sets.

Basically these failures could be due to the:

a) use of old and out-dated methodologies to teach abacus;
b) insensitivity towards the development of new abacus programmes in Taiwan, China and Japan;
c) lack of trained and knowledgeable teachers in abacus and mental arithmetic;
d) lack of a comprehensive mathematics curriculum that includes the use of abacus in the classrooms and also in public examinations;
e) lack of support from various relevant parties such as from the superiors and provision of suitable materials (Naimah, 2001, Liau & Hong, 1994).
f) confusion caused by various mental arithmetic programmes such as *Mokhdar*, fingering mathematics and *Kumon* (Naimah, 2001)

As mentioned earlier, the School Division initially engaged the local Chinese teachers and lecturers (including the researcher himself) with know how of abacus to spearhead the training of other teachers. As we have known the abacus usage has been declining rapidly and even abandoned in the Chinese primary schools since early 80s after the emergence of hand held calculators. As such there was a lapse of 20 to 30 years in which these teachers had not been in touch with the latest developments in abacus instruction outside Malaysia. Many old and out-dated techniques of using the abacus which these teachers were once familiar with were being put into practice again. The old abacus format (5-2) was still being used although it has been discarded in Japan and also in modern China in place of the 4-1 system (Xu, 1992).

Furthermore the old oral rules of moving the beads during computation were still used and translated directly from Chinese to Malay. These oral rules in their original forms are rhythmic and poetic in nature and are to be memorized in order to guide the movement of the beads more quickly and accurately during computation. As such the rules may include the terms such as up, down, enter forward, move backward etc. which when spoken in Malay may seem ridiculous and funny at times especially to the non-Chinese who are using the abacus for the first time. However, it may not be so when recited in Chinese as it flows like poetry. As such many non-Chinese teachers seemed to reject this method of instruction because the rules became lengthy after translation and also sound ridiculous when recited.

Clearly, this direct translation of the content of the curriculum was heavily biased to Chinese culture. Hence it was not well-received by the teachers especially the Malays who are the dominant ethnic group that form the majority of the population in Malaysia. Their enthusiasm towards these abacus instructions certainly was not high although they had been instructed to teach them in their classrooms and also to train other teachers (Naimah, 2001). Thus this vicious cycle of non-compliance by these trained teachers would lead further to more non-compliance by other teachers. This problem was enhanced further by the indecisiveness of the Ministry such as changing the format from 5-2 to 4-1 mid-way through the implementation and ambiguous directives in the curriculum such as the allocation of time and examination for using the abacus, and the unsuitable school age level for this implementation (Naimah, 2001).

Naimah noted that most of the teachers suggested that the most suitable age to implement abacus teaching would be in Year 1 instead of Year 4 as suggested by the Ministry.

Moreover, teachers would not be asked to give an account of what they had done because the abacus usage was not even officially stated in the syllabus. The examinations certainly will not assess the students' ability in this area. Coupled with the lack of supervision from the Ministry, teachers usually escaped detection since the examination results would not show their failure to teach abacus. Thus the lack of a clear and well-defined curriculum about the use of the abacus in mathematics teaching has led to many loop-holes and excuses for the teachers not to practice and introduce it into their Mathematics classrooms (Naimah, 2001). As such many abacus sets sent by the ministry still remained in their pristine condition, yet to be taken out from their wrappers and boxes. Then it came to a stage where nobody was interested about the abacus and the euphoria cooled down and seemingly died a natural death.

The reason given by the School Division about this undesirable state of affairs was that they were not ambitious at the beginning because they were unsure of its effectiveness and also their knowledge about this programme was still limited. Hence, they initially planned to use the abacus as another facilitative tool for the students to calculate and to conceptualize numbers. In order to avoid confusing the students, they even planned to introduce the use of the abacus only from Year 4 onwards instead of Year 1 as suggested by the abacus expert, Xu Sizhong (Xu, 1992). Clearly the contention of the Ministry about the abacus was that it should not be taught as an integral part of the mathematics curriculum but separately as an alternative skill to add and substrate. Thus this explains the inadequate allocation of time (about 8 hours per year) as suggested by the Ministry for this abacus instruction. This certainly did not encourage the use of abacus in the classroom and the programme looked as if it might as well not to be implemented.

In spite of this failure in the government schools, the usage of abacus continued to flourish among the private abacus and mental arithmetic schools and their students' achievement in computation continued to be highlighted by the media and parents alike (Aloha, 2001). More and more private abacus schools (or centres) such as Aloha and UCMAS have been set up and continue to gain support from the public. In 1997, there was a breakthrough in abacus instruction when a suggestion was made that it should include mental arithmetic and the Teachers Training Division (or BPG) was entrusted with the role to implement it.

Following this, the Ministry engaged another private enterprise, UCMAS to undertake the training of teachers and college lecturers. The course conducted was well-received by the teachers and lecturers even among the non-Chinese counterparts. The content of the curriculum was well-organized and comprehensive putting mental arithmetic as the ultimate goal instead of just using the abacus mechanically. The rules of moving the beads have been modified and simplified using the connotations of "+" and "-" instead of the conventional terms described earlier. Newer techniques such as using two hands to move the beads simultaneously instead of one as was commonly used formerly have been introduced to the participants. Certainly, this new and modern way of teaching abacus is less culturally biased and more effective. Moreover, it also includes a vital element in learning abacus, that is, mental arithmetic.

The success of this private enterprise clearly shows that the usage of abacus has been transformed by leaps and bounds through researches conducted in China, Japan and Taiwan (Hwa, 1987; Xu, 1992). The modern-day abacus is not the mechanical abacus that we were once familiar with. It has been transformed and integrated into mental arithmetic that enables someone to mentally calculate arithmetic. Hence, from now on we have to look differently at the future potential of the abacus even in the present midst of technological advancement because it involves the mental or the cognitive aspect of human development.

It is because of this potential that the Ministry is still adamant and insistent on the use of the abacus despite the earlier failure. More coordination among the various divisions and more training programmes have been planned to implement this abacus (and mental arithmetic) programme fully in all the primary schools in 2003 (TED & CDC, 2001). Almost all the Teacher Training Colleges (23) were involved in these training programmes in 2002. However, after half a year of its implementation, these programmes were terminated and replaced by the training programme undertaken by the Chinese expert as stated earlier. The new training programme was scheduled to start in 2003 in tandem with the implementation of AMA for Year 1. Unfortunately, this training and its implementation were delayed because they coincided with the ETeMS (English for the Teaching Mathematics and Science) initiative which was hesitantly scheduled for the same year. Nevertheless, the AMA training was resumed in early 2004. In March of the same year, the Ministry issued a professional circular (*Pekeliling Iktisas*) dated 14th of March 2004 instructing all the primary schools to implement the AMA curriculum in July of the same year starting from Year 1 and subsequently Year 2 in the following year up to Year 3. More and more teachers would eventually be trained in this programme headed by these Chinese experts.

Furthermore, those teachers that were trained would have to conduct in-house training for all teachers involved in teaching Mathematics in their respective schools. The Ministry hopes that in this way the number of teachers trained in AMA could be speeded up. Various factors could affect the training and the implementation of AMA in primary schools. However, in this study, the focus was on the pedagogical aspect of AMA implementation particularly the sequence of three modes of abacus-based calculation as proposed by these Chinese experts.

1.3 Problem Statement

As we know mathematics is the precursor for various kinds of intellectual achievements particularly science and science related studies. Thus it needs to be mastered and deeply understood before anyone can progress further in various related fields. The Malaysian Vision of turning this country into a technologically advanced country by 2020 will be greatly enhanced if the target ratio of 60:40 of science and non-science students in all the higher institutions could be achieved. However, the present situation is still far below that expectation as was reported by a team of researchers from University Science Malaysia (USM) (Lee *et al.*, 1996). Various reasons were cited in this report for the reluctance of students to take science electives but one particularly strong reason cited in this study was the lack of mastery (or foundation) of mathematics and science (Lee *et al.*, 1996).

A Mathematics Working Committee was set up by the Ministry of Education (MOE) in 1993 as part of the measure to tackle the above problem that was by finding ways to improve the mathematics performance of the Malaysian students (MOE, 1993). Based on the information gathered from various parties such as the Inspectors of School, Curriculum Development Centre and various State Education Departments, the Committee reported that a sizable number of teachers lamented that there existed a large number of students having inadequate knowledge and basic skills in following mathematics lessons in secondary schools under the curriculum at that time (KBSM). Furthermore these students were negative towards mathematics. However, students with the background of having primary education in Chinese Primary Schools possessed better basic knowledge in mathematics and tended to like the subject better (pp. 27-28). This further supported the contention that students who are weak in mathematics in the earlier stage of their schooling will also be weak in mathematics (and science also) as they go up to the higher level as reported by Lee *et al.* (1996) above.

The Third International Mathematics and Science Study-Repeat (TIMSS-R) conducted by the IEA in which Malaysia was involved (EPRD, 2001) has shown that Malaysia was in the 16th position out of the 38 countries taking part for Grade 8 Mathematics (average age 14.4 year). Although the Malaysian average score of 519 which was significantly higher than the international average of 487 and also some advanced countries like US and England, its score was still far below from our closest neighbour and competitor – Singapore (604) – and other Far Eastern countries like Korea (587), Chinese Taipei (585) and Japan (579) (Table 1.3). Similar trend was also observed in the 2003 study although Malaysia has shifted to the 9th position (Mullis *et al*., 2004).

Table 1.3 TIMSS-R: Average Scores in Mathematics (Grade 8) According to Countries (Adapted from EPRD, 2001, pp 4-5)

Country	**Average Scores**
Singapore	604
Korea	587
Chinese Taipei	585
Hong Kong	582
Japan	579
Belgium (Flemish)	558
Netherlands	540*
Slovak Republic	534*
Hungary	532*
Canada	531*
Slovenia	530*
Russia	526*
Australia	525*
Finland	520*
Czech Republic	520*
Malaysia	***519***
Bulgaria	511*
Latvia	505*
America	502*
England	496

Country (Cont'd)	**Average Scores**
New Zealand	491
International Average	**487**
Lithuania	482
Italy	479
Cyprus	476
Romania	472
Moldova	469
Thailand	467
Israel	466
Tunisia	448
Macedonia	447
Turkey	429
Jordan	428
Iran	422
Indonesia	403
Chile	392
Philippines	345
Morocco	337
South Africa	275

* Countries with no significant difference with Malaysia

In term of the benchmarking of performance, which measures the quality of achievement of each country, Malaysia only scored 12% for the 90 percentile compared to our neighbour Singapore (46%) and Japan (33%) (Table 1.4). These scores were about triple to that achieved by Malaysian. Furthermore, Singapore and

Japan scored 93% and 89% respectively above the median whereas Malaysia scored 69%, a lag of about 20%.

Table 1.4 Benchmark for Mathematics Achievement in TIMSS-R (EPRD, 2001 p.6)

COUNTRY	PERCENTILE			
	90	**75**	**50**	**25**
***International* Average Score**	*616*	*555*	*479*	*391*
Malaysia (%)	12	34	69	94
Singapore (%)	46	75	93	99
Japan (%)	33	64	89	98
Australia (%)	12	37	73	94
America (%)	9	28	61	88
England (%)	7	24	58	89

Besides that, the existence of disparaging differences in mathematics achievement among the three types of primary school namely the National School (or SK), the National Type Chinese (or SJK(C)) and the National Type Tamil (or SJK(T)) in Malaysia has long been a concern to the educationists and political leaders alike as Malaysia strived to maintain peace and harmony among the various races through equitable sharing of the country economical wealth. As can be seen from Table 1.1 earlier and also its graphic representation in Figure 1.2, the SJK(C) is consistently well ahead of its counterparts from SK and SJK(T) in Mathematics achievement in the yearly Primary School Achievement Test at national level (or UPSR).

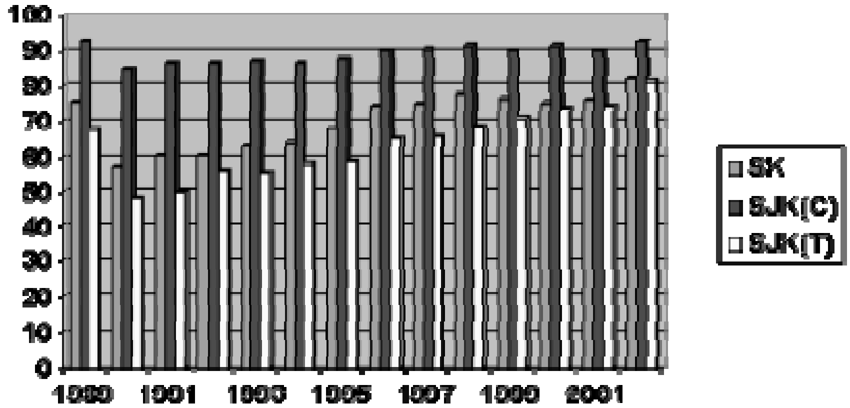


Figure 1.2 National Mathematics Achievement in UPSR According to Types of Primary School from 1989-2002

Referring to Table 1.1 again, the average minimum rates of passes for those years work out to be 70.4%, 63.9% and 89.1 % for SK, SJK(T) and SJK(C) respectively. Clearly the differences are clear and consistent with the SJK(C) maintaining about 90% passes every year whereas the SK and SJK(T) about 70% and 60% respectively. Furthermore as the main objective of primary school Mathematics under the Integrated Curriculum for Primary Schools or commonly know as KBSR is to achieve mastery level for each individual student, consequently a detailed analysis of those who get Grade A and also those who get below that need a closer scrutiny and review.

As can be seen from Table 1.5 and its graphical representation in Figure 1.3, the percentage of the students scored Grade A in SJK(C) (49.1%) is consistently double than their counterparts in SK (22.0%) and quadruple than SJK(T) (11.6%). In other words almost half of the students in SJK(C) pass with distinction in mathematics when they finished their primary school education whereas only a small portion of about 10% of SJK(T) achieved the same performance and one fifth only for the SK. Certainly this disparaging difference among the various school types at national level needs to be addressed and rectified as soon as possible.

Table 1.5 Percentage of Minimum Passes and Grade A in Mathematics for the Primary Schools at National Level from 1995-2002 (Examination Syndicate, MOE, 2003)

	% of Minimum Passes			% of Grade A		
Year	**SK/SRK**	**SJK(C)**	**SJK(T)**	**SK/SRK**	**SJK(C)**	**SJK(T)**
1995	67.9	87.6	59.0	19.3	44.4	7.8
1996	74.5	90.0	65.2	18.3	44.4	7.5
1997	75.0	90.2	65.7	20.9	47.9	9.8
1998	77.5	91.2	68.6	25.3	54.1	13.1
1999	76.2	90.0	70.9	21.5	48.7	11.7
2000	75.2	91.2	73.9	22.4	50.3	12.5
2001	76.0	89.9	74.4	24.0	50.5	14.3
2002	82.0	92.6	81.1	24.2	52.7	15.9
Average				**22.0**	**49.1**	**11.6**

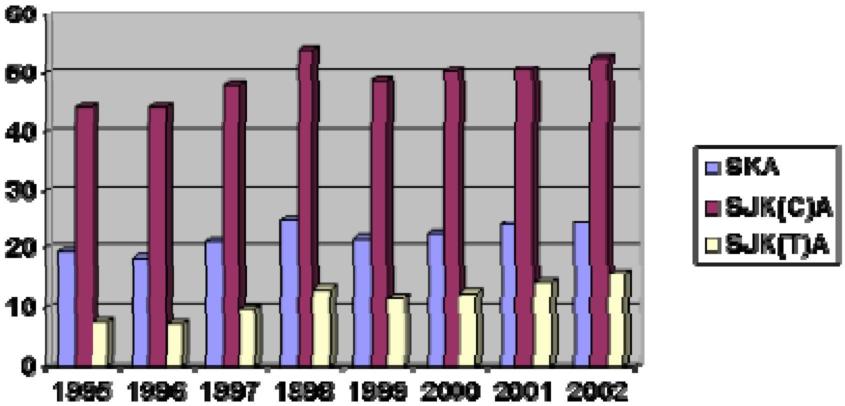


Figure 1.3 National Mathematics Achievement (Grade A) in UPSR According to Types of Primary School from 1995-2002

Similarly these patterns of performance according to school types at the national level are also exhibited at the state level. Take for example the performance of the students in the state of Penang where this research was carried out, the yearly percentage of passes for each type of schools are very similar to the National average (Table 1.6 and Figure 1.4). Thus if grade A is considered to be reaching the mastery level in mathematics, then only about 8.9% of SJK(T) and about 22.6% of SK have achieved the desired targets whereas SJK(C) a satisfactory performance i.e. 50.03%. Thus these rates are far from satisfactory especially for the SJK(T) and moderate for the SK.

However, there still exists room for further improvement in view of the targeted ratio of 60:40 for science and non-science enrolment in universities under Vision 2020.

Table 1.6 Percentage of Minimum Passes and Grade A in Mathematics for the Primary Schools in Penang from 1993-1998 (Examination Unit, Penang State Education Department, 2002)

	% of Minimum Pass			% of Grade A		
Year	**SK**	**SJK(C)**	**SJK(T)**	**SK**	**SJK(C)**	**SJK(T)**
1993	64.16	88.49	53.99	21.21	46.91	5.90
1994	61.95	86.62	60.97	20.16	46.80	6.52
1995	68.86	89.67	56.13	21.76	49.90	7.78
1996	74.53	91.19	64.64	20.46	47.88	7.96
1997	74.46	91.46	66.30	21.83	50.98	10.54
1998	78.06	93.55	67.93	26.92	59.78	14.05
Average	**70.34**	**90.16**	**61.66**	**22.06**	**50.38**	**8.79**

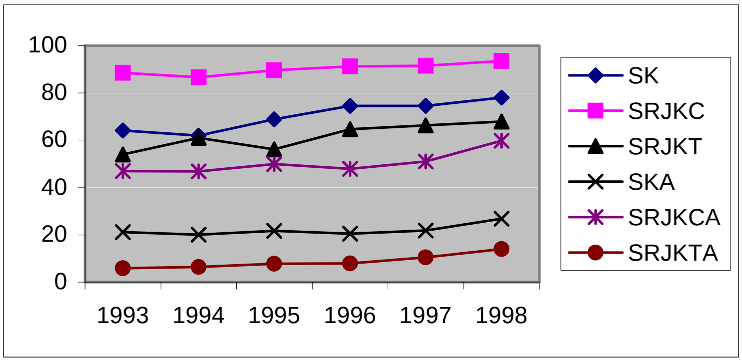


Figure 1.4 Percentage of Minimum Passes and Grade A in Mathematics for the Primary Schools in Penang from 1993-1998

Although various factors could cause this low level of mastery amongst Indian and Malay pupils, many attribute it to the fear and lack of confidence towards Mathematics especially at the beginning stage of schooling as suggested by Prof Dr Anuawar Ali of the National University of Malaysia (Berita Harian, 29 July 95). The answers to why such fear exists and how this fear could be removed form the keys to solve the problem at hand. Malaysian leaders particularly the former Prime Minister himself view this problem seriously and have been instrumental in implementing various counter measures to correct the present situation and to avert further deterioration of the enrollment of science students in higher institutions. Certainly Malaysia needs these human resources in increasing number in order to achieve its dream. Thus, there is a clear need to search for appropriate measures particularly suitable pedagogical alternatives to teach mathematics in view of this problem at hand. And one particular alternative that shows potential and is relevant to this study is the introduction of *Sempoa* or Chinese Abacus for the teaching of Mathematics in various primary schools (Naimah, 2001).

Will the learning of abacus be able to solve the problem described above? Is there any evidence to support its introduction into our primary schools? These are the questions that need to be addressed before we can establish that the abacus is a viable solution to the problem of poor mathematics mastery in primary schools. First let us look at the results of TIMSS-R again. One outstanding feature is that all the top five countries in this study have a culture of using abacus either formally or informally in the teaching and learning of mathematics starting right from the primary or even pre-school level. One may argue that the result of this study may not be relevant and linked to abacus as no abacus is used in the tests that measure the mathematics achievement of the sample. Moreover, the level of academic standard involved in this study is at the secondary level, not the primary level. However, Amaiwa (1999, 2001) has rightly pointed out that the learning of abacus and mental arithmetic in the early years of schooling not only improves the students' mathematics performance compared to the non-abacus learners but it also exhibits an effect which she terms as **ripple effect.** According to this effect the abacus learners not only excel in four of the fundamental arithmetic calculations compared to the non-abacus learners but such mastery also extends into mathematics related skills like solving fraction and worded problems right up to secondary level although usually at this level abacus is not used or taught (Amaiwa, 1999, 2001). Thus, Amaiwa's study has established a link between abacus and mathematics achievement in which the effect of this link becomes increasingly bigger and stronger as the students advance in their studies through secondary and tertiary level. This shows that the use of abacus integrated with mental arithmetic is a viable and profitable pedagogical alternative for us to consider for the purpose of improving the mathematics achievement of our students right from their early years.

Moreover, the abacus is noted for aiding the students to learn and understand mathematics concepts such as the basic concepts of number, place value and the arrangement of digits in a number especially for young children (Xu, 1992). With some simple ways of arranging the beads, it enables numbers to be represented in a concrete visual way, which certainly can help the children to grasp the basic concepts of numbers, particularly in understanding the concept of place value. The arrangement of the rods in abacus in representing a number (left to right) is consistent with the way digits of a number are arranged in the Hindu-Arab number system. This consistency will certainly facilitate the young children to learn the basic concepts of number. The place value of hundred, ten and unit can be easily and concretely displayed using the orderly arrangement of the rods in an abacus, consistent with the order of the digits in a number. This concrete displaying property of abacus is also helpful in overcoming the problems due to the irregular (opposite) construction between the number words in the '-teens' and '-tys' in English and also *belas* and *puluh* in Malay words (but there is no such problem in Chinese Language) in which the place value of the word “-teen” is ambiguous.

Though objects like counting rods and counters are usually used for the purpose of arranging groups into hundred and ten, and units concretely, the effect is not as vivid and clear as in the abacus. Thus the abacus is functioning as an intermediary between concrete quantities and the number concept which is symbolic and abstract. This in-between or transitional role of the abacus in learning the concept of number is advantageous (Tacon and Atkinson, 1997); as it will help the young children who are usually field dependent to learn. Children who are field dependent tend to learn globally instead of analytically (Witkin & Goodenough, 1981). They will be