Evolution of Singapore's School Mathematics Curriculum

Berinderjeet KAUR
National Institute of Education, Singapore
<berinderjeet.kaur@nie.edu.sg>

The evolution of Singapore's school mathematics curriculum is in tandem with developments in the education system of Singapore. In the last six decades, economic policies of the government that are necessary for the survival of Singapore in a fast changing world have shaped the aims of the school mathematics curriculum. The present day curriculum can best be described as one that caters for the needs of every child in school. It is based on a coherent framework that has mathematical problem solving as its primary focus.

Introduction

Singapore's Education System has evolved over time and so has School Mathematics Curricula in Singapore. The present day School Mathematics Curriculum can best be described as one that caters for the needs of every child in school. It is based on a framework that has mathematical problem solving as its primary focus. The attainment of problem solving ability is dependent on five inter-related components – Concepts, Skills, Processes, Attitudes and Metacognition (Ministry of Education, 2012a; 2012b). The three broad aims of mathematics education in Singapore are to enable students to:

- acquire and apply mathematical concepts and skills;
- develop cognitive and metacognitive skills through a mathematical approach to problem solving; and
- develop positive attitudes towards mathematics.

The mathematics curriculum comprises a set of syllabuses spanning 12 years, from primary to pre-university, and is compulsory up to the end of secondary education. Syllabuses for the primary, secondary, pre-university as well as courses of study have specific sets of aims to guide the design and implementation of the syllabuses suited for varying needs and abilities of students.

Developments that Shaped the Education System in the Last Six Decades

The developments from 1946 to 2013 that have shaped the present School Mathematics Curriculum in Singapore are direct consequences of developments in the Education System of Singapore during the same period. Major changes in the education system during the last six decades fall into a number of reasonably well-marked phases in the development of the system. Generally the period from 1946 to 2013 may be categorized into 5 phases of development. These phases are as follows.

1946 – 1965: *Conflict-Resolution and Quantitative Expansion (Yip, Eng & Yap, 1990)*

Two major thrusts and priorities of this period stand out in bold relief. The first is the use of education, in the period after 1959 to resolve some of the pressing conflicts and

2014. In J. Anderson, M. Cavanagh & A. Prescott (Eds.). Curriculum in focus: Research guided practice *(Proceedings of the 37th annual conference of the Mathematics Education Research Group of Australasia)* pp. 24–36. Sydney: MERGA.

dilemmas Singapore faced in the 1950s. The second concerns the pressure to rapidly expand educational opportunities in Singapore with a view not only to democratizing education, but also to using education as a device for achieving national cohesion and the economic restructuring of the society. In 1959 when the People's Action Party (PAP) came to power it acted upon the White Paper of 1956 and put in place a Five-Year Plan in education. The main features of this Plan were:

- equal treatment for the four language streams of education: Malay, Chinese, Tamil and English;
- the establishment of Malay as a national language of the new state;
- emphasis on the study of Mathematics, Science and Technical Subjects.

The government embarked on an accelerated school building programme with the objective of providing a place in school for every child of school-going age in Singapore.

1965 – 1978: *Qualitative Consolidation (Yip, Eng & Yap, 1990)*

1965 witnessed the end of Singapore's merger with Malaysia and the beginning of a new chapter in the history of Singapore. It also marked the beginning of a transformation from statehood to nationhood. Under the leadership of PAP, education remained a key to its survival. Education was crucial in facilitating the nation's economic transformation and of building a socially-disciplined cohesive Singaporean society. There was a shift in emphasis from academic to technical education to provide the manpower base for industrialization. This period also witnessed the onset of systematic improvements via research undertaken by the Ministry of Education (MOE) to the education system.

1978 – 1984: *Refinements and New Strides (Yip, Eng & Yap, 1990)*

By the late 1970s, certain 'cracks' and weaknesses in the system had begun to manifest themselves. Amongst the weaknesses identified by the MOE's Study Team led by Dr Goh Keng Swee (Ministry of Education, 1979) was the high education wastage resulting in low literacy levels in the country. In line with the 'simple objective' of education in Singapore,

> ……to educate a child to bring out his greatest potential so that he will grow into a good man and a useful citizen. (Lee, 1979)

as spelt out by the then Prime Minister of Singapore in 1979 and the findings of the Goh's Report (Ministry of Education, 1979), the New Education System (NES)was introduced in February 1979. The NES introduced ability-based streaming both at the primary and secondary levels of education on the grounds that in the past a common curriculum in the primary and secondary schools had failed to take into consideration variations in the learning capacities of children. Streaming, according to Goh's report, would provide an opportunity for less capable students to develop at a slower pace and it would also enable a child to go as far as he can. Students who are not academically inclined could still acquire basic literacy and numeracy required for skills training. The NES was implemented in 1981. Students were streamed in primary three and secondary one.

In June 1980, the Curriculum Development Institute of Singapore (CDIS) was established. It replaced the Education Development Division of the Ministry of Education, which spearheaded the pioneering efforts in curriculum development for Singapore schools. The main function of CDIS was the development of curriculum and teaching materials. It was directly involved in the implementation of syllabuses and systematic

collection of feedback at each stage of implementation for the next cycle of syllabus revision (Ang & Yeoh, 1990).

1984 – 1996: *Towards Excellence in Schools (Yip, Eng & Yap, 1990)*

1985 marked a watershed in the economic development of Singapore. Based on two key reports, one in Singapore (Economic Committee, 1986) and another in the United States (Tan, 1986), the Minister for Education in 1986 enunciated that future education policies in Singapore would be guided by three principles. These were:

- education policy must keep in pace with the economy and society;
- basics – Languages, Science, Mathematics and Humanities will be stressed to encourage logical thinking and life-long learning;
- creativity in schools must be boosted through a 'bottom up' approach whereby the initiative must come from principals and teachers instead of from the Ministry (Tan, 1986).

As part of an on-going process of self-improvement, in 1987 based on the report, Towards Excellence in Schools (Ministry of Education, 1987), schools became the center of attention. This was a result of the premise that the goal of excellence in education could only be achieved through better schools (Tan, 1987). Several refinements to the NES had been made since its implementation in 1981. In 1991, the level at which streaming in the primary school was carried out was changed to primary four. In 1994, the Secondary Normal (Technical) Course was introduced to secondary one normal stream students.

1996 – 2013*: The Way Forward… (Kaur, 2002)*

In 1997, the Prime Minister, Mr Goh Chok Tong in his speech (Goh, 1997) at the opening of the Seventh International Conference on Thinking held in Singapore signaled that changes had to be made to the existing education system. These were necessary to prepare young Singaporeans for the new circumstances and new problems that they will face in the new millennium. He emphasized that we must ensure our young can think for themselves, so that the next and future generations can find their own solutions to whatever new problems they may encounter. He also announced at the opening of the conference that Singapore's vision for meeting this challenge is encapsulated in four words: THINKING SCHOOLS, LEARNING NATION.

Three initiatives were launched in Singapore's education system in 1997. They are National Education, Information Technology and Critical and Creative Thinking (Ministry of Education, 1998). To forge the vision THINKING SCHOOLS, LEARNING NATION (TSLN) and to push forward the initiatives of information technology and critical and creative thinking, changes were recommended in four main areas, namely curriculum, teaching, teachers and assessment (Ministry of Education, 1997). To accommodate the recommendations, the MOE initiated a content reduction of all curricular subjects. Every subject underwent a content reduction ranging from 10 – 30 % and the reduced content syllabuses were effective in 1999. The amount of curriculum time for each subject remained the same. The time freed by the content reduction supported the implementation of the three initiatives.

Since 1997, the MOE has begun a shift in strategic paradigm from an efficiency-driven education system to an ability-driven (ADE) one. To achieve this, MOE is equipping

schools with the hardware and software necessary to bring about the change. In 2000, at the MOE work plan seminar for school leaders it was noted that the hardware to 'make ADE happen' was already in place. To build up the software the emphasis is on the people factor – school leaders who create an environment conducive to learning and innovation and teachers who are thinking and caring professionals who believe and share the vision – TSLN (Ministry of Education, 2000).

The Teach Less, Learn More (TLLM) initiative was launched in the education system in 2005 (Shanmugaratnam, 2005). TLLM builds on the groundwork laid in place by the systemic and structural improvements under TSLN, and the mindset changes encouraged in schools. It continues the TSLN journey to improve the quality of interaction between teachers and learners, so that our learners can be more engaged in learning and better achieve the desired outcomes of education. TLLM aims to touch the hearts and engage the minds of our learners, to prepare them for life. It reaches into the core of education - why we teach, what we teach and how we teach. It is about shifting the focus from "quantity" to "quality" in education. It emphasizes "more quality" in terms of classroom interaction, opportunities for expression, the learning of life-long skills and the building of character through innovative and effective teaching approaches and strategies. It also emphasizes "less quantity" in terms of rote-learning, repetitive tests, and following prescribed answers and set formulae.

Developments in School Mathematics Curriculum during the Last Six Decades

A school curriculum can be defined in terms of its aims, content and resources, teaching and learning strategies, and assessment practices (Wong, 1991). However it also exists within a broader context involving the physical, political, cultural, economic, and social environments that define and constrain its role in educating the people. It is clear from the review of the developments in the education system of Singapore in the last six decades that the aims of the school curriculum are shaped by economic policies of the government that are necessary for the survival of Singapore in a fast changing world. School mathematics curriculum as part of the school curriculum has played a significant role in the economic development and progress of Singapore during the last six decades. A review of developments in school mathematics syllabuses follows.

Diverse Beginnings…

Up to the late 1950s, schools in Singapore were mainly vernacular in nature, i.e. there were Chinese, Malay, Tamil and English schools. The language of instruction in Chinese schools was Chinese and their curricula were adopted from China. Likewise the language of instruction in English schools was English and their curricula were adopted from Britain. Therefore several mathematics syllabuses were in use across Singapore, with each school adopting their own. The first local set of syllabuses for mathematics was drafted in 1957 and published in 1959 (Lee, 2008). The set of syllabuses for Primary and Secondary schools were contained in a single booklet. The syllabuses adopted a spiral approach and were for all schools irrespective of their language streams. This set of syllabuses marked the first step towards the localization of mathematics education in Singapore (Lee, 2008).

In 1959, after the PAP came into political power, the government placed emphasis on educating the masses. In schools, the study of mathematics, science and technical subjects

were emphasized. The first local set of syllabuses was used across all schools and little consideration was given to differences in the mathematical abilities of the students. The secondary school mathematics syllabuses referred to as Syllabus B prepared students for the mathematics examinations of the Cambridge Certificate of Education conducted by the University of Cambridge Local Examination Syndicate (UCLES).

Keeping in Line with World Trends

A revision of the first local set of syllabuses for both the primary and secondary schools took place in late 1960's in response to the "Math Reform of the 1960's". The primary school mathematics syllabus was revised in 1971 with emphasis on an outcomes based approach to the teaching of mathematics in the primary schools (Wong & Lee, 2010). It was again revised in 1979 and algebra was part of the curriculum for grades 5 and 6 (Lee, 2008).

For secondary school mathematics the revised syllabus known as Syllabus C was implemented in the early 1970's (Lee, 2008). Towards the end of the 1970s the syllabus underwent yet another revision resulting in Syllabus D. At the secondary level, all students took the mathematics (elementary) course. At the upper secondary level, the more able students studied an additional mathematics course. Both courses were based on the "Ordinary" level syllabuses of the University of Cambridge Local Examination Syndicate (UCLES).

Since the 1980's Singapore secondary students have been doing the Syllabus D. The Ministry of Education issues the syllabus for the Lower Secondary levels. This syllabus covers topics in Arithmetic, Mensuration, Algebra, Graphs, Geometry, Statistics and Trigonometry. For each topic, the syllabus describes the instructional objectives, lists the main concepts and learning outcomes. These topics are a subset of the syllabus for the "Ordinary" level UCLES mathematics examination.

Mathematics for Every Child

In 1981, the NES (Ministry of Education, 1979) was implemented. The goal of the NES was to provide for every child in the system. Due to low achievement in mathematics, it was decided that the primary mathematics curriculum (detailed syllabuses, textbooks, workbooks and teacher guides) would be developed by the CDIS. Drawing on the expertise of international consultants, curriculum writers at CDIS produced the first Primary Mathematics Curriculum in 1981. The curriculum writers at CDIS were experienced teachers from schools and the Ministry of Education. The curriculum adopted the Concrete-Pictorial-Abstract approach to the teaching and learning of mathematics. This approach provides students with the necessary learning experiences and meaningful contexts, using concrete manipulatives and pictorial representations to construct abstract mathematical knowledge.

In 1983, the mathematics team writing the primary curriculum materials, led by Dr Kho, at CDIS made a breakthrough to address difficulties students were having with word problems. They introduced the 'Model Method' (Kho, 1987) in the curriculum for primary 5 and 6 students in the late 1980s. Now, students are introduced to the method in primary 1. This method is now synonymous with Singapore maths wordwide! The method uses a structured process whereby students are taught to visualise abstract mathematical

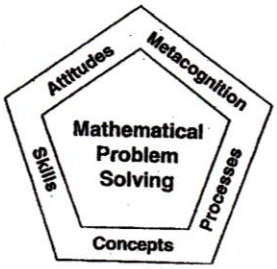
relationships and their varying problem structures through pictorial representations (Ferrucci, Kaur, Carter, & Yeap, 2008). In the NES, primary school students are either offered the standard mathematics course or the foundation mathematics course. The foundation mathematics course caters for the less mathematically able students and the syllabus is a subset of the standard mathematics course.

Also in 1981, the Ministry of Education produced a mathematics syllabus for the Express and Special courses of study in the secondary school by arranging the topics in Syllabus D into a four-year programme. Students in the Express and Special course of study sat for the GCE 'O' level examination at the end of the four years. The mathematics syllabus of the Normal course students was a subset of that for the Express course. These students took the 'N' level examination at the end of four years.

In 1988, the Curriculum Development Division of the Ministry of Education set up a Mathematics Syllabus Review Committee to review and revise the mathematics syllabuses in use since 1981. The goal of the committee was to study the adequacy of the syllabuses in meeting the needs of the students and to revise the syllabuses to reflect appropriate recent trends in mathematics education (Wong, 1991). It was during this review that the committee felt that besides elaborating the aims and objectives, a framework was necessary to describe the philosophy of the revised curriculum. Hence, the framework shown in Figure 1 that spells out the primary focus of the mathematics curriculum which is ***mathematical problem solving*** was developed. This coherent framework connects the 'product' conception of mathematics and the 'process' aspect of it and links both of them to the five factors that facilitate the development of mathematical problem solving (Wong & Lee, 2010). It also represents an organising framework that "presents a balanced, integrated vision that connects and describes the skills, concepts, processes, attitudes and metacognition" (Leinwand & Ginsburg, 2007, p. 32). Figure 1 also shows that the five components of the framework, concepts, skills, attitudes, metacognition and processes have remained steadfast though at periodic revisions to the school mathematics curriculum some refinements have been made to the components. These refinements have heightened emphasis on aspects of the components based on research in mathematics education and careful deliberations of mathematics educators at both the Ministry of Education and National Institute of Education in Singapore.

In 1990, the revised Mathematics Syllabus for the New Education System was implemented. The revised syllabuses for both the primary and secondary schools placed emphasis on problem solving. The use of heuristics to solve problems was propagated in the curriculum through in-service training of teachers, textbooks and assessment tasks. A predominant heuristic in primary mathematics was the 'model drawing' approach (Wong & Lee, 2010).

In 1992, the mathematics syllabus for the Normal (Technical) course students was produced by the Ministry of Education (Ministry of Education, 1992). The Normal course mathematics syllabus was also renamed as Normal (Academic) course mathematics syllabus A (4010). The Normal (Technical) course mathematics syllabus is a sub-set of the Normal (Academic) course syllabus. The Normal (Technical) course mathematics syllabus T (4012) was implemented in 1994 when the Normal (Technical) course came into being at the secondary one level for the first time.



Primary Goal: Mathematical Problem Solving

Component	1991- 2000	2001- 2006	2007- 2012	2013 - beyond
Concepts	- Numerical - Geometrical - Algebraic - Statistical	- Numerical - Geometrical - Algebraic - Statistical	- Numerical - Geometrical - Algebraic - Statistical - Probabilistic - Analytical	- Numerical - Algebraic - Geometrical - Statistical - Probabilistic - Analytical
Skills	- Estimation & Approximation - Mental calculation - Communication - Use of mathematical tools - Arithmetic manipulation - Algebraic manipulation - Handling data	- Estimation & Approximation - Mental calculation - Communication - Use of mathematical tools - Arithmetic manipulation - Algebraic manipulation - Handling data	- Numerical calculation - Algebraic manipulation - Spatial visualization - Data analysis - Measurement - Use of mathematical tools - Estimation	- Numerical calculation - Algebraic manipulation - Spatial visualization - Data analysis - Measurement - Use of mathematical tools - Estimation
Attitudes	- Appreciation - Interest - Confidence	- Appreciation - Interest - Confidence - Perseverance	- Beliefs - Appreciation - Interest - Confidence - Perseverance	- Beliefs - Interest - Appreciation - Confidence - Perseverance
Meta cognition	- Monitoring one's own thinking	- Monitoring one's own thinking	- Monitoring of one's own thinking - Self-regulation of learning	- Monitoring of one's own thinking - Self-regulation of learning
Processes	- Heuristics - Deductive reasoning - Inductive reasoning	- Heuristics - Thinking Skills	- Reasoning, communication and connections - Applications and modeling - Heuristics - Thinking Skills	- Reasoning, communication and connections - Applications and modeling - Thinking skills and heuristics

Figure 1. Evolution of the School Mathematics Curriculum Framework

Consolidation of Content

In 1997, following the infusion of three significant initiatives in the education system, namely Thinking Schools, Learning Nation (TSLN), National Education (NE) and Information and Communication Technology (ICT) there was a need to create time for teachers to implement the initiatives. So, in order for teachers to infuse thinking skills, integrate information technology and deliver key NE messages, curriculum content was reduced up to 30% for most subjects. Therefore in 1998, the mathematics syllabus underwent a content reduction exercise. The following rationale guided it.

- The learning of mathematics is sequential and hierarchical in nature. Therefore, essential topics and skills removed from one level were transferred to another level in order to ensure continuity in the learning of the subject.
- Topics that were core content, i.e. essential as the foundation for further mathematics learning; developed the desired outcomes of the syllabuses; and provided continuity and completeness were retained.
- Topics that were less fundamental and not connected to other topics in the syllabus; which placed heavy emphasis on mechanical computation; which overlapped with those taught at other levels; that were too abstract for the intended level and concepts/skills that were taught in other subjects, were removed from the syllabus.

Mathematics for Knowledge Based Economies

In 1998, following the content reduction exercise, a revision of the syllabuses was undertaken to:

- update the content to keep abreast with the latest developments and trends in Mathematics education;
- explicate the thinking processes inherent in the subject and to encourage the use of IT tools in the teaching and learning of Mathematics;
- ensure the content meets the needs of the country in the next millennium (21st century).

Resulting from the revision, a couple of changes were made to the reduced content syllabus. It must be noted that the revised syllabus and reduced content syllabus were almost the same. A re-organisation of the content was mainly carried out. There was minimal increase in the content to emphasise the development of the thinking skills and help in the attainment of the objectives. A critical appraisal of the framework was also undertaken. Two changes were made to the framework of the 1990 syllabus. Under the arm of processes "Deductive reasoning and Inductive reasoning" were replaced by "Thinking skills" which covered a much wider range of skills that students were encouraged to use when solving problems. Also an additional attribute, perseverance was added to the arm of Attitudes.

This revised curriculum was implemented in 2001. Beginning from 2001, textbooks for the primary school mathematics were privatised. This was done so that schools would have more choice of curriculum materials though the scope of the content remained the same. All the books that were available for use in schools must be approved by the Ministry of Education for use in Singapore schools for a specified period of time. CDIS never produced curriculum materials for secondary school mathematics. The first local textbook series for secondary schools was published in 1969 by Teh (1969).

Since 2001, the school mathematics curriculum has undergone two successive periodic revisions, one in 2006 and the last one in 2012. These six year cycles of revision ensure that the curriculum remains relevant in this rapid changing and highly competitive and technologically driven world. As people are the only resource of Singapore, education is the key to the success of its economy and in turn survival (Goh, 2001). At present it may be said that every child in school does mathematics that is suited to his or her ability. School mathematics curriculum emphasizes a balance between mastery over basic skills and concepts and the application of higher order thinking skills to solve mathematical problems.

Mathematics Courses at School

Primary School Mathematics

Primary school comprises six years of schooling. The first four years constitute the foundation stage and the next two years the orientation stage. During the foundation stage emphasis is on building a strong foundation in the English Language, Mathematics and Mother Tongue language. All students take the same course for mathematics. In the orientation stage students are grouped according to ability. Subject-based banding is adopted. Students either take the Foundation Mathematics or Standard Mathematics course of study. The Foundation Mathematics syllabus is a sub-set of the Standard Mathematics course of study. Students in the Foundation Mathematics course do not do the topics algebra and ratio in primary 5 and 6, while those in the Standard Mathematics course do. Also for the other topics the depth of the content varies as shown in Table 1. Table 1 shows an extract from the primary school mathematics syllabuses (Ministry of Education, 2012a).

Table1
An extract from the primary school mathematics syllabus

Standard Mathematics Course	Foundation Mathematics Course
Rate (P5) • Rate as the amount of a quantity per unit of another quantity • Finding rate, total amount, or units given the other two quantities • Solving word problems involving rate ***Distance, time and speed*** (P6) • Concepts of speed and average speed • Relationship between distance, time and speed (exclude conversion of units e.g. km/h to m/min) • Writing speed in different units such as km/h, m/min, m/s and cm/s • Solving up to 3-step word problems involving speed and average speed	***Rate*** (P5) • Rate as the amount of a quantity per unit of another quantity • Finding rate, total amount, or units given the other two quantities • Solving up to 3-step word problems involving rate
Percentage (P5) • Expressing a part of a whole as a percentage • Use of % • Finding a percentage part of a whole • Finding discount, GST and annual interest • Solving up to 2-step word problems involving percentage ***Percentage*** (P6) • Finding the whole given a part and the percentage • Finding the percentage increase / decrease • Solving word problems involving percentage	***Percentage*** (P6) • Expressing a part of a whole as a percentage • Use of % • Finding a percentage part of a whole • Finding discount, GST and annual interest • Solving up to 2-step word problems involving percentage

The recommended curriculum time per week for mathematics in the primary school is shown in Table 2. It is apparent from Table 2 that primary 5 and 6 students in the Foundation course devote more time than their peers in the Standard course to mathematics.

Table 2
Curriculum time per week for mathematics (primary)

Grade Levels	Hours per week
Primary 1 - 2	4
Primary 3 - 4	5.5
Primary 5 – 6 (Standard Mathematics)	5
Primary 5 – 6 (Foundation Mathematics)	6.5

Secondary School Mathematics

Students sit a national examination called the Primary School Leaving Examination (PSLE) at the end of Primary six. The examination assesses student's suitability for secondary education and places them in an appropriate secondary school course that matches their learning ability. Three Courses are available at the secondary school level. Students undergo four or five years of secondary education with different emphases.

- Special Course – a four-year course leading to the Singapore-Cambridge General Certificate of Education (GCE) 'O' level examination. In this course, students study their mother tongue at an advanced level, in addition to the usual humanities, mathematics and science subjects.
- Express Course – also a four-year course leading to the GCE 'O' level examination. In this course students study their mother tongue at an ordinary level and are offered a curriculum similar to that in the Special course.
- Normal Course – a four-year course leading to the GCE 'N' level examination. A fifth year is available to students who do well in this examination to prepare for and take the GCE 'O' level examination. Students in this course follow either the Normal (Academic) or Normal (Technical) curriculum. In the N(A) curriculum, they will learn English, mother tongue, mathematics and a range of subjects similar to those in the Special and Express courses. In the N(T) course, students will learn English, mother tongue at a basic level emphasizing oral/aural competence and reading comprehension, mathematics, computer applications and subjects with a technical and practical bias such as technical studies.

As mathematics is a compulsory subject for students in school, the mathematics curriculum at the secondary school level is differentiated to cater to the needs and abilities of students in the different courses. Core mathematical concepts are common to all courses and the content for the Special Course is identical to the Express Course. The content for the Normal (Academic) Course is a subset of the content for Special/Express Course while that of the Normal (Technical) Course is a subset of the Normal (Academic) Course. For all the three courses most of the topics taught at the various year levels for mathematics are similar. However the depth to which they are taught at a particular year level differs. Table 3 shows an extract from the secondary school mathematics syllabuses (Ministry of Education, 2012b) highlighting the varying depth.

Table 3
An extract from the secondary school mathematics syllabus

Secondary One - Algebra
Special / Express Course
• Algebraic expressions and formulae • Use letters to represent numbers • Express basic arithmetic processes algebraically • Substitute numbers for words and letters in formulae and expressions • Simple algebraic manipulation • Manipulate simple algebraic expressions – include collecting like terms and removing brackets • Simple linear equations • Solve simple linear equations • Solve problems involving linear equations – emphasize understanding of the problem leading to formulation of mathematical expressions/equations
Normal (Academic) Course
• Algebraic expressions and formulae • Use letters to represent numbers • Express basic arithmetic processes algebraically • Substitute numbers for letters in formulae and expressions • Simple algebraic manipulation • Manipulate simple algebraic expressions – include collecting like terms and removing brackets
Normal (Technical) Course
• Algebraic expressions and formulae • Concept and notation • Use letters to represent numbers • Express basic arithmetic processes algebraically • Substitution • Substitute numbers for letters in expressions and formulae (exclude expressions with brackets & expressions involving squares and high powers) • Simplification • Simplify simple algebraic expressions (include collecting like terms but exclude removing of brackets at this level & expressions involving squares and higher powers)

The recommended curriculum time per week for mathematics in the secondary school is shown in Table 4. Students in the Special, Express and Normal (Academic) courses spend the same amount of time per week doing mathematics. Students in the Normal (Technical) course spend relatively much more time doing mathematics compared to their peers in the other courses of study.

Table 4
Curriculum time per week for mathematics (secondary)

Secondary Mathematics Course	Hours per week
Special / Express Course	2.5 - 3
Normal (Academic) Course	2.5 - 3
Normal (Technical) Course	4 - 5

Concluding Remarks

Singapore's education system has evolved over time into one that offers quality education for all in school. In tandem Singapore's school mathematics curriculum too has evolved over time. Today every child in school has the opportunity to do mathematics that is suited to his or her ability. As people are the only resource of Singapore, education is the key to the success of its economy and in turn survival (Goh, 2001). School mathematics curriculum, at present, emphasizes a balance between mastery over basic skills and concepts in Mathematics and the application of higher order thinking skills to solve mathematical problems.

For any curriculum revision to succeed changes must be systematic; they cannot be piecemeal efforts independent of one another and most importantly no initiative in education can succeed without the enthusiastic participation of every teacher (Wee, 1997). It is hoped that with the close monitoring and support given to teachers the gap between the intended curriculum and implemented curriculum would be as narrow as possible. A nation-wide paradigm shift in education is also necessary for the success of the TSLN vision, the essence of which is that any syllabi, curriculum, and much of our other teaching / learning material would become obsolete with time but a thinking culture as a way of life would hold us steadfast all the way (Nathan, 2001).

References

Ang, W.H., & Yeoh, O.C. (1990). 25 years of curriculum development. In J.S.K. Yip & W.K. Sim (Eds.), *Evolution of educational excellence – 25 Years of education in the Republic of Singapore* (pp. 81-106). Singapore: Longman Singapore Publishers (Pte) Ltd.

Economic Committee. (1986). *Report of the economic committee - The Singapore economy: New directions*. (Chaired by BG Lee Hsien Loong). Singapore: Ministry of Trade and Industry.

Ferrucci, B.J., Kaur, B., Carter, J. A,. & Yeap, B.H. (2008). Using a model approach to enhance algebraic thinking in the elementary school mathematics classroom. In C.E. Greenes & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp 195-209). Reston, VA: National Council of Teachers of Mathematics.

Goh, C.T. (1997). *Shaping our future: "Thinking Schools" and a "Learning Nation"*. Speeches, 21(3): 12-20. Singapore: Ministry of Information and the Arts.

Goh, C.T. (2001). *Shaping lives, moulding nation*. Speech at the Teachers' Day Rally, Friday 31st August 2001. Singapore: Ministry of Education.

Kaur, B. (2002). Singapore's school mathematics curriculum for the 21st century. In J. Abramsky (Ed.), *Reasoning, explanation and proof in school mathematics and their place in the intended curriculum – Proceedings of the QCA International Seminar*, 4-6 October 2001 (pp 166 – 177). London: Qualifications and Curriculum Authority, UK.

Kho, T.H. (1987). Mathematical models for solving arithmetic problems. *Proceedings of the fourth South East Asia conference on mathematics (ICMI-SEAMS)* (pp. 345-351). Singapore: Institute of Education.

Lee, K.Y. (1979). Letter in response to the report on the Ministry of Education by Dr Goh and his team. In Ministry of Education (Ed.), *Report on the Ministry of Education by Dr Goh and his team* (pp iii-vi). Singapore: Ministry of Education.

Lee, P.Y. (2008). Sixty years of mathematics syllabus and textbooks in Singapore (1949-2005). In Z. Usiskin & E. Willmore (Eds.), *Mathematics curriculum in pacific rim countries – China, Japan, Korea and Singapore* (pp 85-94). Charlotte, North Carolina: Information Age Publishing.

Leinwand, S., & Ginsburg, A. (2007). Learning from Singapore math. *Educational Leadership*, 65 (3), 32-36.

Ministry of Education (1979). *Report on the Ministry of Education by Dr Goh and his team*. Singapore: Author.

Ministry of Education (1987). *Towards excellence in schools*. Singapore: Author.

Ministry of Education. (1992). *Mathematics syllabus – Secondary 1 and 2 Normal (Technical) Course*. Singapore: Curriculum Planning Division, Ministry of Education.

Ministry of Education (1997). *Towards thinking schools*. Singapore: Author.

Ministry of Education (1998). *Mathematics Newsletter*, 1(17). Singapore: Curriculum Planning and Development Division, Ministry of Education.

Ministry of Education. (2000). *Proceedings of MOE work plan seminar: Ability-driven education – Making it happen*. Singapore: Author.

Ministry of Education (2012a). *Primary mathematics teaching and learning syllabus*. Singapore: Author.

Ministry of Education (2012b). *O-level, N(A)-level & N(T)-level mathematics teaching and learning syllabus*. Singapore: Author.

Nathan, J.M. (2001). Making "thinking schools" meaningful: Creating thinking cultures. In J. Tan, S. Gopinathan, & W.K. Ho (Eds.), *Challenges facing the Singapore Education system today* (pp. 35-49). Singapore: Prentice Hall.

Shanmugaratnam, T. (2005). *Teach less learn more (TLLM)*. Speech by Mr Tharman Shanmugaratnam, Minister of Education, at the MOE workplan seminar 2005. Retrieved 24 April 2014 from http://www.moe.gov.sg/media/speeches/2005/.

Tan, T.K.Y. (1986). *Speech delivered at the Nanyang Technological Institute*, 22 July 1986.

Tan, T.K.Y. (1987). Speech delivered at the First Schools Council Meeting. *Straits Times*, 14 Jan 1987.

Teh, H. H. (Ed.) (1969). *Modern mathematics for Singapore schools*. Singapore: Pan Asian Publishers.

Wee, H.T. 1997. *Towards Thinking Schools, Learning Nation. Open letter from the Director-General of Education to principals and teachers*. Singapore: Ministry of Education.

Wong, K.Y. (1991). Curriculum development in Singapore. In C. Marsh, & P. Morris (Eds.), *Curriculum development in East Asia* (pp. 129-160). London: Falmer Press.

Wong, K.Y. & Lee, N.H. (2010). Issues of Singapore mathematics education. In F.K.S. Leung & Y. Li (Eds.), *Reforms and issues in school mathematics in East Asia* (pp. 91-108). Sense Publishers.

Yip, S.K.J., Eng, S.P. & Yap, Y.C.J. (1990). 25 Years of educational reform. In J.S.K. Yip & W.K. Sim (Eds.), *Evolution of educational excellence – 25 Years of education in the Republic of Singapore* (pp. 1-30). Singapore: Longman Singapore Publishers (Pte) Ltd.