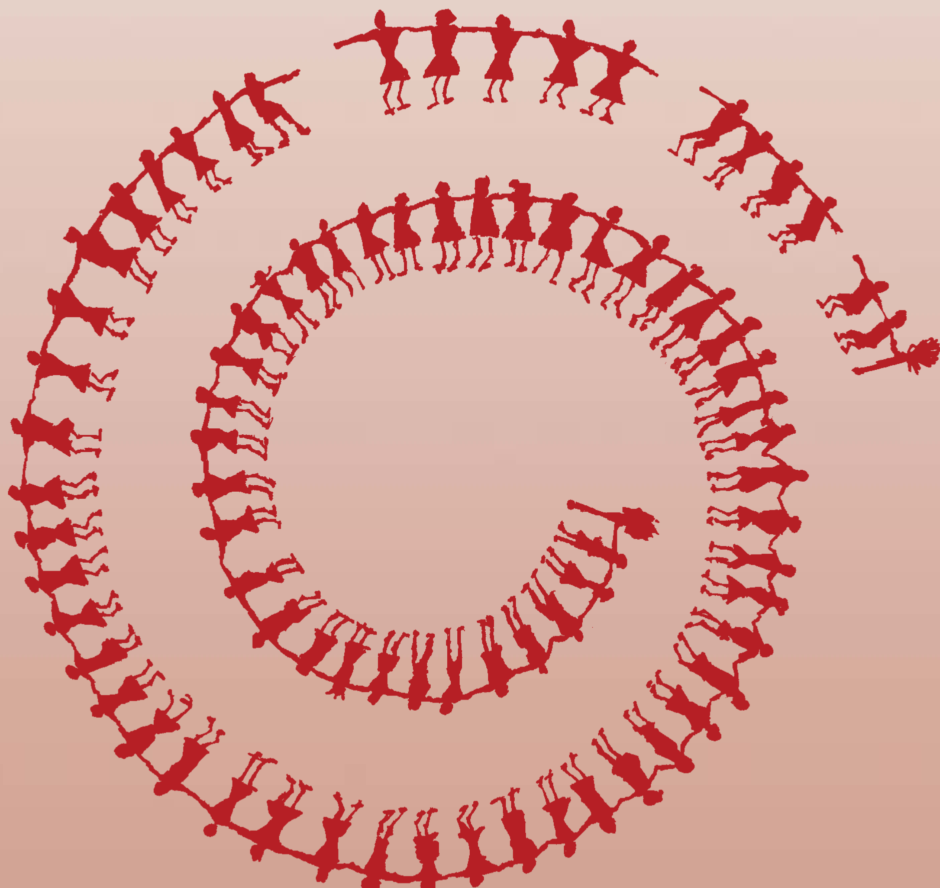
Report No. 43

South Asia Human Development Sector

# Strengthening Mathematics Education in Sri Lanka

July 2011



Discussion Paper Series

Report No 43

**South Asia: Human Development Unit**

# STRENGTHENING MATHEMATICS EDUCATION IN SRI LANKA

July 2011

**Discussion Paper Series**

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# List of acronyms

| | |
|---|---|
| DOE | Department of Examinations |
| EPD | Education Publications Department |
| GCE O/L | General Certificate of Education, Ordinary Level |
| GCE A/L | General Certificate of Education, Advanced Level |
| ICT | Information and Communication Technologies |
| ISA | In-service advisor |
| MOE | Ministry of Education |
| NCOE | National Colleges of Education |
| NCTM | National Council of Teachers of Mathematics |
| NEC | National Education Commission |
| NEREC | National Education Research and Evaluation Centre |
| NIE | National Institute of Education |
| PISA | Program of International Student Assessment |
| SLAAED | Sri Lanka Association for the Advancement of Education |
| SLAAS | Sri Lanka Association for the Advancement of Science |
| TIM | Teacher’s Instructional Manual |
| TIMSS | Trends in Mathematics and Science Study |

# EXECUTIVE SUMMARY

## Introduction

A well-informed and knowledgeable community is of vital importance for the economic and social development of a modern society. The knowledge and skills required for present day activities are much more complex than those required in the past. Today, many jobs require expert thinking and non-routine analytical skills, to identify and solve problems. Mathematics education focuses on developing a person's analytical and problem solving abilities. Thus a high quality mathematics education will ensure that students develop the skills that are essential not only in science and technology, but also in everyday life and the workplace.

The government of Sri Lanka, recognizing the need for a high quality mathematics education has implemented several reforms in the recent past. Studies on these reforms have been carried out and measures have been taken to address the shortcomings. Although the progress achieved is commendable, there is still room for improvement in certain important aspects of the learning teaching process.

## Learning Achievements in Mathematics

National cognitive achievement tests conducted by NEREC for Grade 8 students reveal a substantial improvement in mathematics learning outcomes in the middle school from 2005 to 2008. Among girls, the mean score increased from about 46 percent in 2005 to approximately 52 percent in 2008, and among boys, the mean score rose from about 44 percent in 2005 to approximately 49 percent in 2008.

Both urban and rural schools show an improvement in the achievement levels in mathematics learning outcomes. Although rural schools show a greater improvement between 2005 and 2008, there is still a disparity in the achievement levels of the two regions. In the urban areas, the mean score increased from about 52 percent in 2005 to approximately 53 percent in 2008. The mean score for rural areas increased from about 44 percent to approximately 49 percent during the same period.

There is a substantial difference between the test scores of students in Type 1AB schools and other schools, although all schools show an increase in test scores from 2005 to 2008. For Type 1AB schools, the mean score increased from 56.0 percent in 2005 to 58.4 percent in 2008. For Type 1C schools, the mean score increased from 45.3 percent in 2005 to 47.8 percent in 2008 and for Type 2 schools, the mean score increased marginally from 42.9 percent in 2005 to 43.1 percent in 2008. Most of the children from poor and disadvantaged communities attend Type 1C or Type 2 schools which cater to 60 percent of the students.

An improvement is seen in all five sub-skills in mathematics, namely, knowledge and skills, communication, making connections, reasoning and problem solving. The test scores reveal that communication is the best mathematical sub-skill. This has improved from a facility index of 52 percent in 2005 to 56 percent in 2008. The greatest improvement is seen in the sub-skill problem solving for which the facility index increased from 48 percent in 2005 to 55 percent in 2008. For the two sub-skill ‘knowledge and skills’ and ‘making connections’, the facility index increased from 45 percent in 2005 to 50 percent in 2008. The weakest sub-skill in mathematics is reasoning, for which the facility index increased from 37 percent in 2005 to 42 percent in 2008.

Efforts should be made to improve these levels especially in the higher order skill of mathematical reasoning. Attention should also be paid to reduce the gap that exists between the test scores of type 1AB schools and other schools. The causes for regional disparities should also be considered and addressed.

There is an 11 percent increase in the GCE O/L pass rates in mathematics from 2002 to 2009. Approximately 270,000 students from 6,600 schools sit the GCE O/L examination annually. Since at least a simple pass grade in mathematics is required to qualify for the GCE A/L, an increase in mathematics pass rates positively affects the number who qualify for the GCE A/L. Between the years 2005 and 2009, GCE O/L mathematics pass rates increased from 44 percent to 51 percent. In the year 2009, 49 percent of the students who sat the GCE O/L qualified for the GCE A/L.

Although there has been an improvement in the GCE O/L mathematics pass rates, the mean score has consistently been low up to 2009 (32±2). There are various factors contributing to the poor performance in mathematics at the GCE O/L examination. The subject knowledge of teachers is one of the major factors. Students passing from one grade to another without gaining the knowledge and skills that are essential to cope with the work in the higher grade is another contributing factor. However, the most important factor is that all students have to follow the same mathematics syllabus and sit the same mathematics examination paper at the GCE O/L.

There is a disparity in the GCE O/L mathematics pass rates of the provinces**.** For the year 2009, the highest pass rate of 60 percent was observed in the Western province which is the most economically advanced province, while the lowest pass rate of 42 percent was seen in the Uva and North Central provinces. The Eastern and Central provinces also performed relatively poorly, with pass rates of 45 percent and 44 percent respectively. The other four provinces, Northern, Southern, North-Western and Sabaragamuwa performed approximately equally, with pass rates between 51 percent and 54 percent. There is also significant disparity in pass rates between zones within provinces. For mathematics, most of the low performing zones are in the Northern, Central, Eastern, Uva and North Central provinces. The geographical distribution of the zones clearly indicates that the lower performing zones are mainly from conflict effected regions and plantation areas. Efforts should be made to reduce these differences by providing better education services to disadvantaged provinces and rural areas.

In 2009, the GCE O/L mathematics pass rates in national and provincial schools were 74 percent and 44 percent respectively. The ratio of those sitting for the GCE O/L mathematics paper from national and provincial schools is approximately 1:4. This means that 20 percent of the students contribute to a pass rate of 74 percent while 80 percent contribute to a pass rate of 44 percent. Clearly, mathematics education in provincial schools needs to be improved greatly.

During the past five years, there has been high variation in the GCE A/L examination pass rates with respect to the main subjects. Annually, about 20,000 students sit as school candidates for the GCE A/L combined mathematics paper, while approximately 30,000 students sit for the biology paper. In 2009, the GCE A/L pass rate in combined mathematics was 44.9 percent. This is low, in comparison for instance to the pass rate of 75 percent in biology. Although a credit pass in mathematics at the GCE O/L examination is required to follow the physical science stream at the GCE A/L, the prescribed competency in mathematics may be insufficient to cope with the standard of mathematics expected at the GCE A/L. The present system where all students following the same mathematics syllabus at the GCE O/L prevents curriculum developers and teachers from catering to the requirements of students who wish to follow mathematics at the GCE A/L and beyond. Between 2004 and 2009, pass rates in combined mathematics have decreased by approximately 8 percent.

## The National Education Policy and Curriculum Reforms

Sri Lankan policy makers since the 1930s have advocated the provision of widespread access to primary and secondary education. This has enabled the country to attain a high level of human development. In 1972, a common general curriculum was introduced and mathematics was taught to all students in grades 1 to 9. In 1991, the government established the National Education Commission (NEC) which formulated a National Education Policy. Reforms based on this policy were implemented in 1997.

Curriculum revisions were carried out in 2007 and at this juncture Sri Lanka adopted a competency based learning teaching assessment model. The reforms at this stage were introduced to address the issue that students were unable to demonstrate acceptable levels of achievement in applying their learning to everyday situations. Their skills in open ended problem solving and decision making were weak and few were able to demonstrate their ability to use higher order skills. The main aim of the mathematics curriculum under these reforms is to create individuals who are able to think mathematically and apply mathematical knowledge effectively and responsibly in problem solving and decision making. However, the early experience of curriculum implementation in grades 6 and 10, and in grades 7 and 11, was that there are shortcomings related to the design, planning, development and implementation of the curricula (NIE, 2009).

## Mathematics Standards

International trends in mathematics education focus on developing individuals with the reasoning abilities and communication skills required to solve everyday problems, by integrating the traditional content of mathematics to make meaning of the real world. Many leading international educational jurisdictions regard the Standards for School Mathematics as a global benchmark (McCaul, 2007). The National Council of Teachers of Mathematics (NCTM) defines standards as the mathematical content and processes that students should know and be able to use as they progress through school. NCTM sets out five content standards which describe explicitly the five strands of content that students should learn, and five process standards highlighting the ways of acquiring and applying content knowledge. The Sri Lankan content standards and process standards are aligned with these international standards.

## Mathematics Teaching Strategy

### Primary Education (Grades 1 to 5)

The actions recommended by the Presidential Task Force in 1997 for primary education, based on the proposals of the NEC, included the following: an integrated curriculum incorporating the Mother Tongue, Religion, Mathematics and Environment Related Activities, a child centred approach, a learning teaching process based on guided play, activity and desk work, identification of entry level competencies and essential learning competencies, and continuous assessment throughout the learning teaching process (NEC, 2003).

These reforms were carried out successfully and the recommendation of the NEC in 2003 was that the curriculum developed in 1997 should be retained for primary education, but that the training of mathematics should be strengthened to raise the levels of attainment.

The Mathematics Teacher's Instructional Manuals (TIMs) for the primary education cycle contain 10 common competencies to be developed in key stages 1, 2 and 3. Each TIM also specifies entry level competencies and essential learning competencies for each grade, the subject content and the learning teaching methodology. The syllabus has a spiral approach, and concepts are introduced in different grades with increasing depth. Textbooks which are aligned with the TIMs are provided to students in grades 3 to 5.

### Junior Secondary Education and the GCE O/L Cycle (Grades 6 to 11)

The education reforms proposed in 1997 for junior secondary education were in contrast to the primary education reforms, weak, both conceptually and implementation-wise, lacking clear direction and cohesion. Several problems associated with mathematics education at the secondary level were identified and new proposals were put forwarded in 2003 to improve the quality of mathematics education at the junior secondary level (NEC, 2003).

A description of the aims of learning mathematics, the learning teaching process, the subject content, competencies, competency levels, activity continuum and assessment criteria is provided in the TIMs of grades 6 to 11. There are a common set of aims of learning mathematics and 31 common competencies specified for grades 6 to 11. A study on the implementation of the mathematics and science curricula revealed that although the curriculum strands and general aims are aligned with international standards, there are several shortcomings in the TIMs. The study revealed that the activities in the TIMs focus mainly on basic concepts and mathematical skills and do not provide opportunities for open ended and creative problem solving. Learning outcomes are not included for the process strands and specific criteria for assessing students during each activity are not provided. Guidance is also not provided on how adjustments are to be made to accommodate student needs or time constraints.

Mathematics is taught in the classroom through a series of activities. All activities are described in step-by-step detail, follow the same format, and prescribe the same teaching strategy. The activities are designed in a sequence according to the 5E learning cycle of engagement, explanation, exploration, elaboration and evaluation. Teachers use only the activities specified in the TIMs in their lessons and lack sufficient flexibility to develop their own lessons or use different teaching strategies.

The Education Publications Department (EPD) is responsible for the production and distribution of textbooks. The government provides mathematics textbooks to all students in grades 3 to 11. The textbooks are based on the syllabi provided by the NIE. The present mathematics textbooks contain many errors. By investing in hiring a team of competent and qualified writers, the EPD can ensure that students are provided with high quality error free textbooks.

Teachers with sound mathematical knowledge and effective teaching practices are essential for imparting excellent mathematics education. There are approximately 2400 teachers without the required training who teach mathematics in the secondary education cycle. Studies conducted by the NIE and the DOE reveal the urgent need for a comprehensive teacher development program to enhance the knowledge and skills of mathematics teachers.

### GCE A/L Cycle (Grades 12 and 13)

There are three mathematics courses offered by GCE A/L students. All Physical Science students offer combined mathematics. Higher mathematics is offered on average by less than 10 Physical Science students. Mathematics is offered on average by less than 75 Arts students.

Mathematics and science at the senior secondary education level are available at only 600 schools which account for about 25 percent of the schools with GCE A/L classes. Recognizing the need to expand science and mathematics education, the NEC proposed that GCE A/L science and mathematics streams be introduced in 1,745 Type 1C schools across the country in a phased program (NEC, 2003). However, there has been little success in following up on these recommendations. The number of school candidates offering combined mathematics as a subject at the GCE A/L has not increased during the past six years. There is a decreasing trend in mathematics pass rates during these years.

The syllabi and TIMs for the senior secondary education cycle are prepared by the NIE in consultation with university academic staff. A competency based curriculum was introduced in 2009. The 5E learning teaching model is advocated in the TIMs. However, most teachers adopt lecture style teaching due to lack of time. The government does not provide mathematics text books for A/L students. The EPD has translated several English medium mathematics textbooks of international standard which have assisted students greatly and this practice should be continued.

## Avenues and Pathways for the Future

The cognitive capacities and the mental development of students vary. This needs to be taken into consideration when secondary school curricula are being formulated. Countries such as the U.K. and Singapore address this by providing different mathematics syllabi to cater to the varying needs and abilities of students. The Ministry of Education could consider adopting a similar practice and have two syllabi, an advanced mathematics syllabus for students intending to pursue mathematics-intensive subjects in high school, and a second practical mathematics syllabus for the others.

It is essential to ensure that all mathematics teachers are subject-competent and have sound teaching practices since they play one of the pivotal roles in providing students with a high quality mathematics education. In consequence, it is of vital importance that a comprehensive teacher development program which provides teachers with both the required subject knowledge and training in good teaching practices is initiated. The program should incorporate the objectives of the curriculum so that all teachers have a better understanding of the expectations of the curriculum.

Since there is no systematic monitoring to identify shortcomings in the curriculum, an on-going monitoring program needs to be designed and implemented to ascertain whether the objectives of the curriculum are being met.

To ensure that students are provided with quality textbooks, the EPD needs to invest in hiring a team of competent and qualified writers. Writers need to be made aware of the aims of the competency based curriculum so that the textbooks are aligned with these aims. Final evaluation of the textbooks needs to be undertaken by at least two subject experts.

To overcome shortcomings in the TIMs, learning outcomes need to be provided not only for the content standards but for the process standards as well. The process standards reasoning and problem solving need to be included in the activities. Clear guidelines need to be provided on how the process standards are to be assessed. Attention needs also to be paid to the horizontal integration of subjects and the use of technology. Teachers need to be encouraged to develop their own lesson plans and to use different teaching strategies.

# Introduction

A well-informed and knowledgeable community is of vital importance for the economic and social development of a modern society. The knowledge and skills required for present day activities are much more complex than those required in the past. Today, many jobs require expert thinking and non-routine analytical skills, to identify and solve problems. Mathematics education focuses on developing a person's analytical and problem solving abilities. Thus a high quality mathematics education will ensure that students develop the skills that are essential not only in science and technology, but also in everyday life and the workplace. Mathematics is also an exciting subject which challenges the mind and offers opportunities for students to enhance their creative abilities.

The government of Sri Lanka, recognizing the need for a high quality mathematics education, has implemented several reforms in the recent past. Studies on these reforms have been carried out and measures have been taken to address the shortcomings. Although the progress made is commendable, there is still room for improvement in certain important aspects of the learning teaching process.

This paper is organized as follows. The first section presents the learning achievement of students in mathematics at national examinations. The second section reviews how national education policies and curriculum reforms have been developed in Sri Lanka. The third section describes Sri Lankan mathematics standards. Then it discusses the mathematics curriculum and teaching strategy at different levels of the education cycle. The paper ends with proposals for improving mathematics education in Sri Lanka.

# Section one: learning achievements in mathematics

The analysis presented in this section is based on the achievements of students in mathematics at 3 separate examinations; (1) the national assessment of learning outcomes of grade 8 students conducted by the National Education Research and Evaluation Center (NEREC), University of Colombo, (2) the GCE O/L examination at the end of grade 11 conducted by the Department of Examinations (DOE), and (3) the GCE A/L examination at the end of grade 13 conducted by the Department of Examinations. The national assessment of learning outcomes was a randomized sample based test administered to approximately 10,000 students in government schools who have completed grade 8. The GCE O/L examination is taken annually by approximately 270,000 students from 6,600 schools and the GCE A/L examination (science stream) is taken annually by approximately 50,000 students from 700 schools.

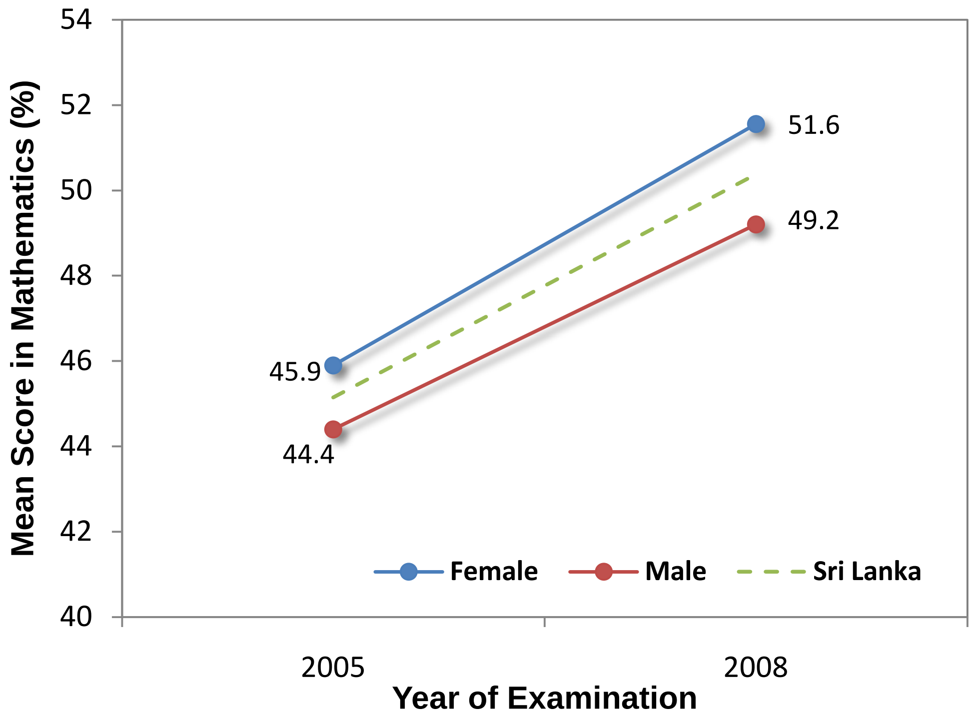
## National Assessment at Grade 8

*Time trend of learning outcomes:*

The trends of the learning outcomes of Grade 8 students for mathematics are presented in Figure 1. There is an improvement in the achievement levels in mathematics between 2005 and 2008. This improvement is seen for both males and females, although a slightly greater increase in mathematics scores is seen for females, compared to that of their male counterparts.

The national mean score for mathematics increased from 45.2 percent in 2005 to 50.4 percent in 2008. For females, the mean score increased from 45.9 percent in 2005 to 51.6 percent in 2008. For males, the mean score increased from 44.4 percent in 2005 to 49.2 percent in 2008. The difference between the 2005 and 2008 mean scores is statistically significant at 99 percent. The increases shown here are quite substantial considering that the two evaluations were carried out within a period of 3 years. Further national assessments are required to test the reliability and magnitude of these highly positive findings.

**Figure 1: The time trend of learning outcomes of grade 8 students for mathematics, males and females, 2005-2008**



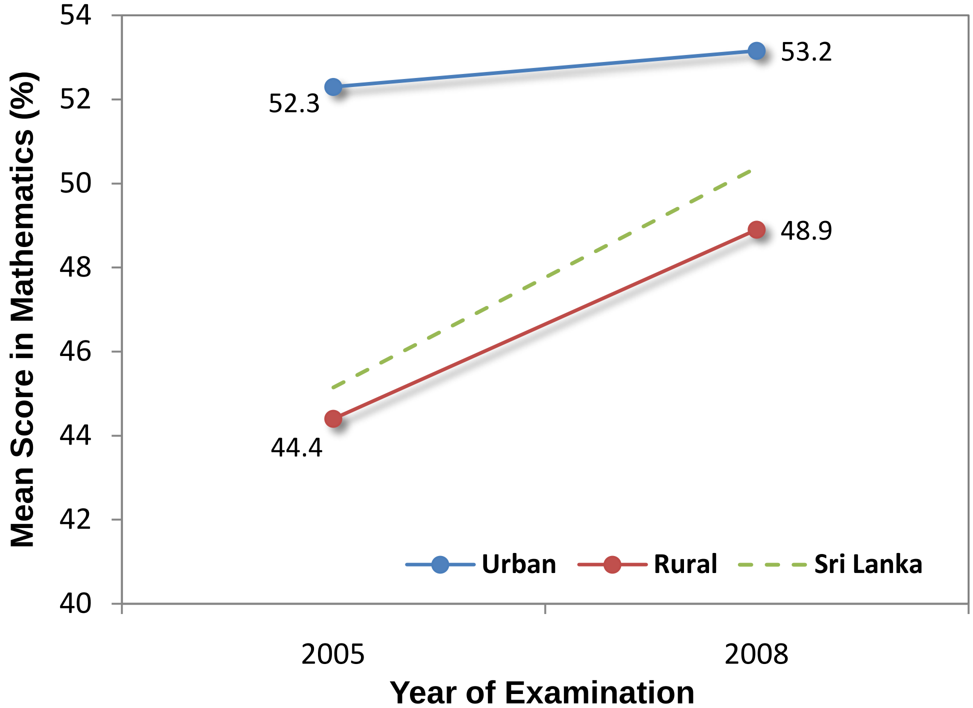

Source: National Assessments of Learning Outcomes, Grade 8, 2005 and 2008, National Education Research and Evaluation Center, University of Colombo.

*Achievement levels in mathematics learning outcomes by Sector:*

The achievement levels in mathematics learning outcomes for the urban and rural sectors are presented in Figure 2. An increase in the mean score is seen in both the urban and rural sectors. In comparison to the urban sector, the rural sector shows a greater improvement in the mathematics learning outcomes of students, closing the gap between the two.

For the urban sector, the mean score in mathematics increased from 52.3 percent in 2005 to 53.2 percent in 2008. For the rural sector, the mean score increased from 44.4 percent in 2005 to 48.9 percent in 2008. During the years from 2005 to 2008, the gap between the two sectors has reduced from about 8 percent to approximately 4 percent.

**Figure 2: The achievement levels in learning outcomes of the urban and rural sectors, grade 8, mathematics, 2005-2008**




*Source: National Assessments of Learning Outcomes, Grade 8, 2005 and 2008, National Education Research and Evaluation Center, University of Colombo.*

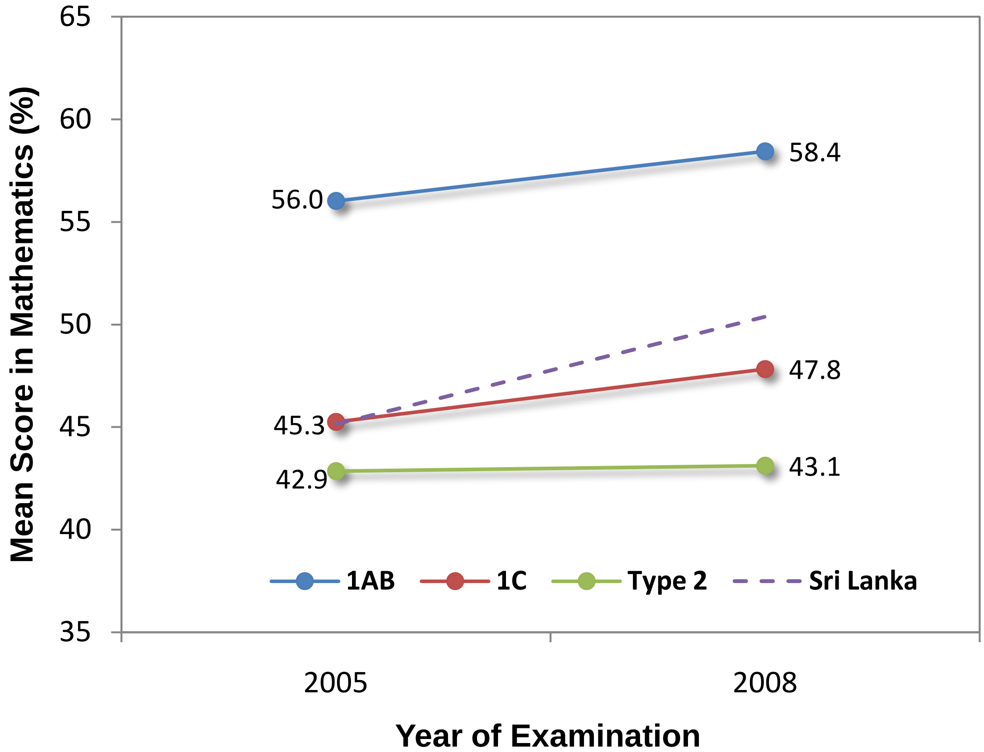
*Achievement levels in mathematics learning outcomes by Type of School:*

The increase in achievement levels in mathematics learning outcomes seen between 2005 and 2008 is desegregated further by type of school and presented in Figure 3. Type 1AB schools which are large and better funded have classes from grade 1 to 13 and offer the full primary, junior secondary and senior secondary school curriculum (Aturupane, 2009). A large number of these schools are National Schools managed directly by the Ministry of Education. Type 1C schools which are also large schools have grades from 1 to 13, and offer a full curriculum with the exception of Science for the senior secondary cycle (GCE A/L). Type 2 schools run from grade 1 to 11 and offer the school curriculum up to the junior secondary level (GCE O/L). All Type 1C and Type 2 schools are provincial schools managed by provincial education authorities.

For mathematics, Type 1AB schools perform the best, while Type 1C schools come next, followed by Type 2 schools. Type 1AB and Type 1C schools show significant improvement in student performance between 2005 and 2008. Type 2 schools show a very slight improvement which is not significant.

For Type 1AB schools, the mean score increased from 56.0 percent in 2005 to 58.4 percent in 2008. For Type 1C schools, the mean score increased from 45.3 percent in 2005 to 47.8 percent in 2008. For Type 2 schools, the mean score increased marginally from 42.9 percent in 2005 to 43.1 percent in 2008.

**Figure 3: The achievement levels in learning outcomes by School Type, grade 8, mathematics 2005-2008**



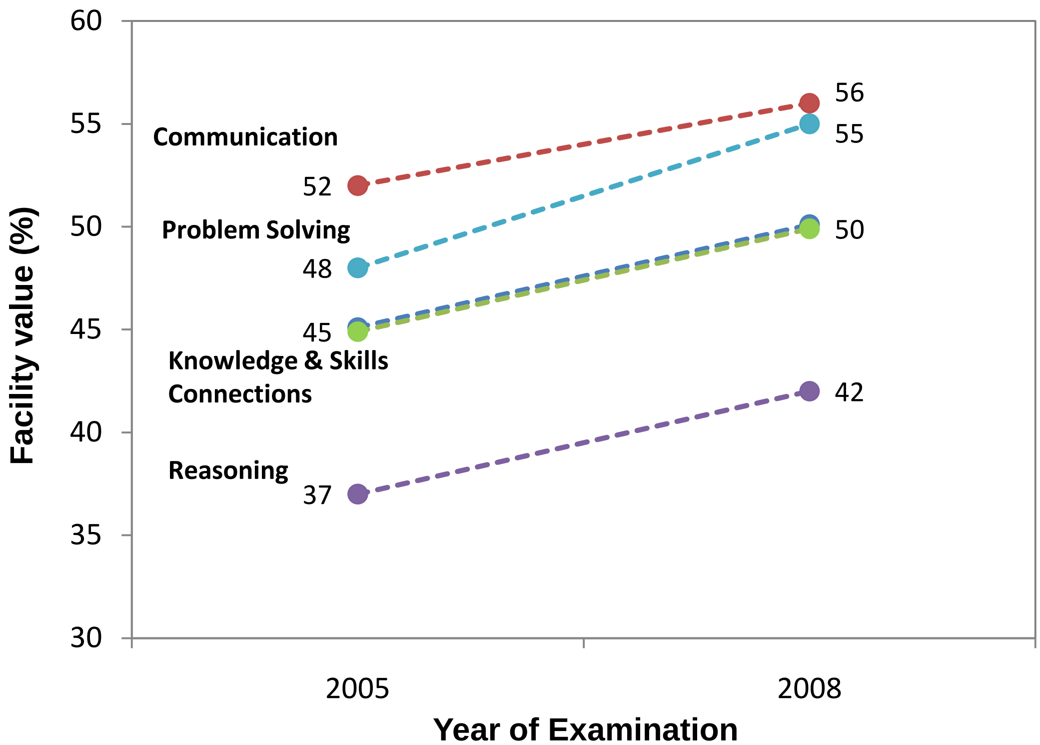

*Source: National Assessments of Learning Outcomes, Grade 8, 2005 and 2008, National Education Research and Evaluation Center, University of Colombo.*

The finding that the performance of students in Type 1C and Type 2 schools is worse than the performance of those in Type 1AB schools is important for policy decisions. There are approximately 6,000 schools which are either Type 1C or Type 2 schools catering to approximately 60 percent of the students. These schools are attended by children from poor and disadvantaged communities. Thus, more public resources need to be channelled to upgrade the level of these schools. On the other hand, if the level of education in Type 1C schools can be improved up to the level in Type 1AB schools by providing a better teaching learning environment and, if students studying in Type 2 schools can be given the opportunity to move into Type 1C schools after the primary education cycle, a larger percentage of students can be provided with a mathematics education equivalent to that in Type 1AB schools. This agrees with the government plan to develop 1000 secondary schools.

*Achievement levels in mathematics learning outcomes by Sub-skills:*

The test items of the grade 8 national assessments have been designed to test the learning outcomes specified by the curriculum developers of each subject (NEREC, 2008). In mathematics, knowledge and skills, communication, making connections, reasoning and problem solving abilities have been tested. The achievement levels of students under each of these sub-skills can be analyzed using the facility values (discrimination indices) of the test items. In calculating the facility value, NEREC has used the percentage of students who have been able to answer the given item correctly. Figure 4 shows the results for each of the above sub-skills for 2005 and 2008.

**Figure 4: The learning outcomes by Sub-skills, grade 8, mathematics, 2005-2008**




*Source: National Assessments of Learning Outcomes, Grade 8, 2005 and 2008, National Education Research and Evaluation Center, University of Colombo.*

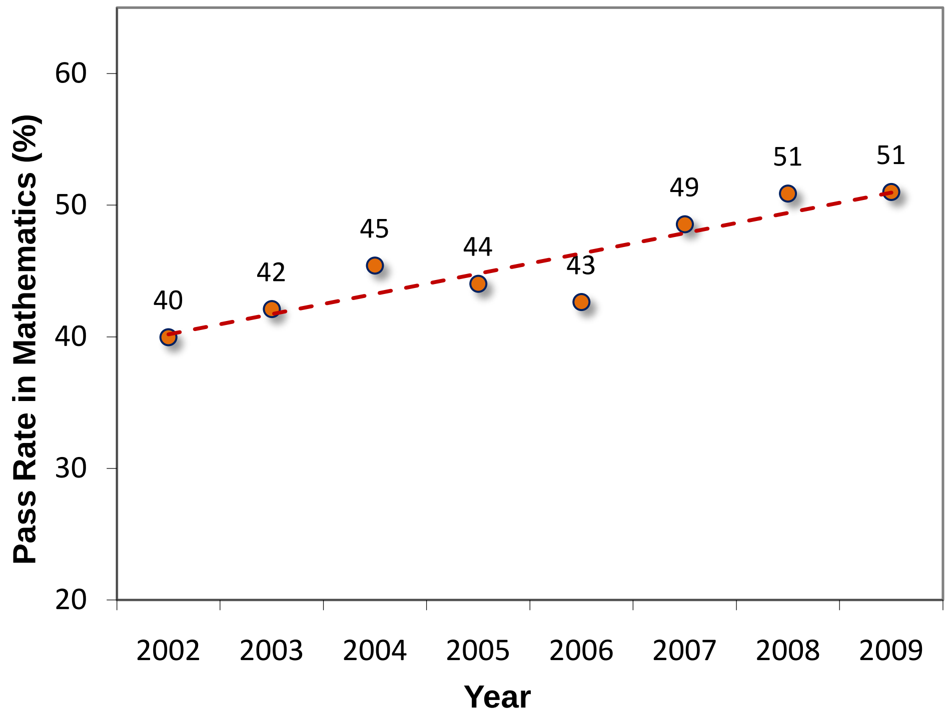
On average, there is an improvement in all five sub-skills between 2005 and 2008. Communication is the best mathematics sub-skill among students. This has improved from a facility index of 52 percent in 2005 to 56 percent in 2008. The greatest improvement is seen in the sub-skill problem solving for which the facility index has increased from 48 percent in 2005 to 55 percent in 2008. Both the sub-skill ‘knowledge and skills’ and the sub-skill ‘making connections’ have improved from a facility index of 45 percent to a facility index of 50 percent from 2005 to 2008. The weakest sub-skill in mathematics is reasoning. This is consistent with the performance of students at the GCE O/L examination, where the poorest performance is seen in geometry which tests the skills of reasoning to a high degree.

## Performance at the GCE O/L examination

*Time trend of examination pass rates:*

The GCE O/L pass rates in mathematics for school candidates in the country as a whole between 2002 and 2009 indicate an 11 percent improvement (see Figure 5).

**Figure 5: Performance of school candidates at the GCE O/L examination 2002 – 2009**




*Source: World Bank estimates, based on Department of Examinations data, 2002-2009*

As at least a simple pass grade in mathematics is required to qualify for the GCE A/L, an increase in mathematics pass rates at the GCE O/L positively affects the number that qualifies for the GCE A/L. The number that qualifies for the GCE A/L is now reaching 50 percent of those sitting the examination[1]. However, when the GCE O/L mathematics mean scores of the past 5 years are compared, no significant change is seen. The mean scores are at a very low value (32±2). Thus, the positive trend seen may reflect the effects of adjustments made to examination pass marks rather than the actual achievement levels of students.

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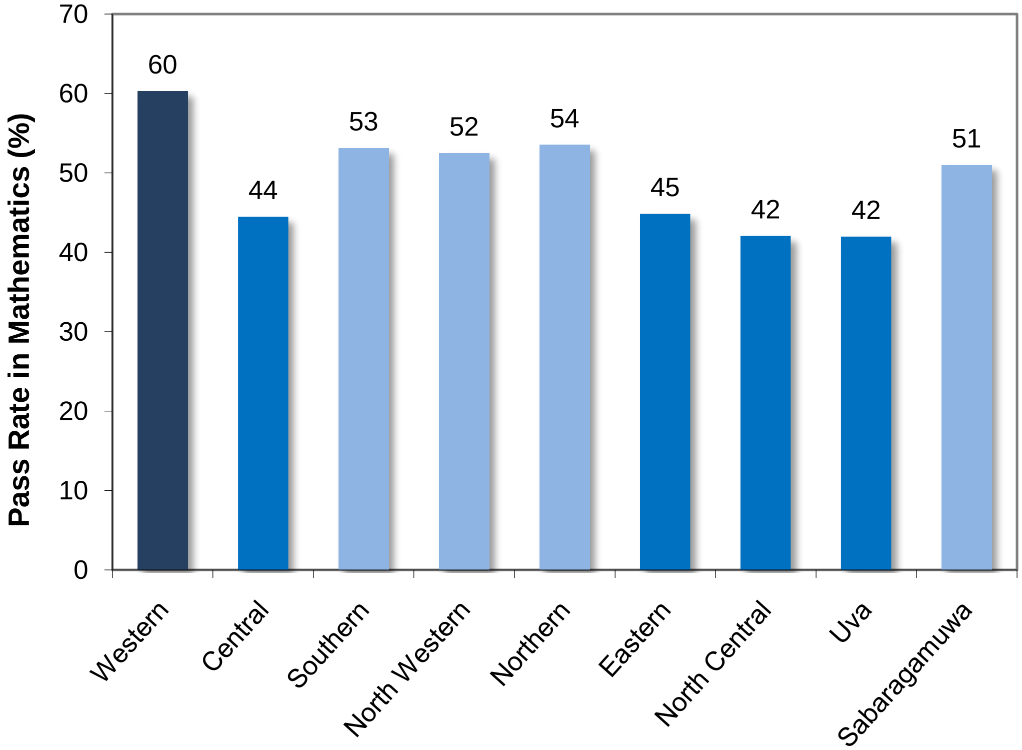
[1] Since the time period given for answering the mathematics paper was increased by 30 minutes in 2010, a direct comparison with past data cannot be carried out.

*Regional disparities in examination pass rates:*

Figure 6 presents a comparison of GCE O/L mathematics pass rates in 2009, across all nine provinces. The highest pass rate of 60 percent is seen in the Western province, while the lowest pass rate of 42 percent is seen in the Uva and North Central provinces. The Eastern and Central provinces also performed relatively poorly, with pass rates of 45 percent and 44 percent respectively. The other four provinces, Northern, Southern, North-Western and Sabaragamuwa performed approximately equally, with pass rates between 51 percent and 54 percent.

**Figure 6: Performance of students in mathematics at the GCE O/L examination in 2009, by Province**

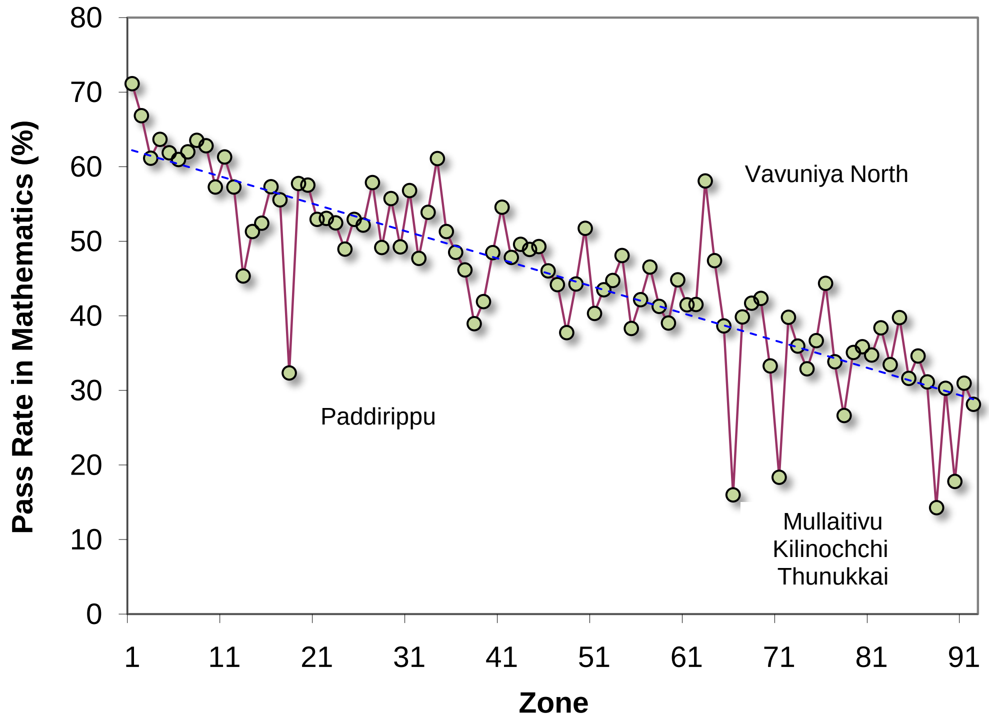



*Source: World Bank estimates, based on Department of Examinations data, 2006*

As such, the provinces fall into three categories, with one group of four provinces at the bottom, a second group of four provinces clustered in the middle and the Western province an outlier at the top. The Western province is the most economically advanced and educationally developed region of the country. The Southern, North-Western and Sabaragamuwa provinces too have traditionally been educationally developed regions.

The provincial performance does not reveal the disparities within the provinces, especially the performance in disadvantaged areas, relative to the high performance in urban centres. The data shown in Figure 7 reveals the high disparity in examination pass rates in individual education zones. The zones are ranked according to their performance in 2006. Any zone depicted higher than the fitted line has an improved performance in 2009 compared to 2006 and vice versa.

**Figure 7: Performance of students in mathematics at the GCE O/L examination in 2009, by Zone**




*Source: World Bank estimates, based on Department of Examinations data, 2006 and 2009*

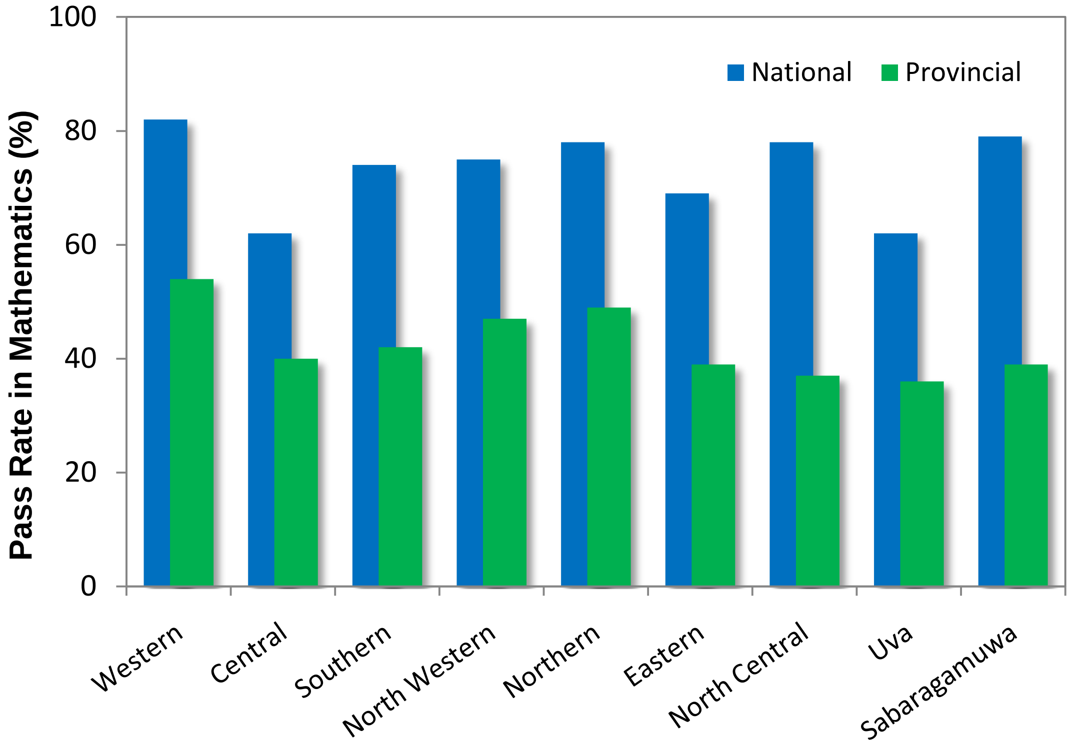
Note: The zones are arranged in the order of highest performing zone to lowest performing zone relative to 2006 performance. Only the identities of a few selected zones are given.

For mathematics, in 2009, the highest pass rate is 71% in the Colombo zone whilst the lowest is 14% in Thunukai . Performance in the zones, Mullaitivu, Padirippu, Killinochchi and Thunukai has dropped by more than a 10 percent compared to the 2006 performance. Approximately 25 percent of the zones show more than a 10 percent improvement in performance with Vavuniya North showing the highest at a 26 percent increase. In general, for mathematics, a number of zones in the Northern and Eastern provinces have shown a decrease in performance possibly due to an increase in hostilities in these regions between 2005 and 2008. However, since less than 100 students sat the GCE O/L examination from each of these zones in 2009, statistically meaningful comparisons cannot be made. Many students from these zones may have been displaced and have taken the examination under disrupted circumstances.

*Performance of National and Provincial schools:*

Government schools are categorized into two types, national and provincial schools. While the national schools are managed by the Ministry of Education (line ministry), the provincial schools are managed by the individual provinces. Most of the national schools are well established schools. Better performing students from poor households are allowed to enter these schools through the Grade 5 scholarship examination. In general, compared to the provincial schools, the national schools are provided with better facilities and well trained teachers. Thus, students entering national schools are of superior achievement and are exposed to a better teaching-learning environment, and hence perform well at the GCE O/L examination.

**Figure 8: Comparison of student performance in mathematics at the GCE O/L examination in 2009 at National and Provincial schools**




*Source: World Bank estimates, based on Department of Examinations data, 2009*

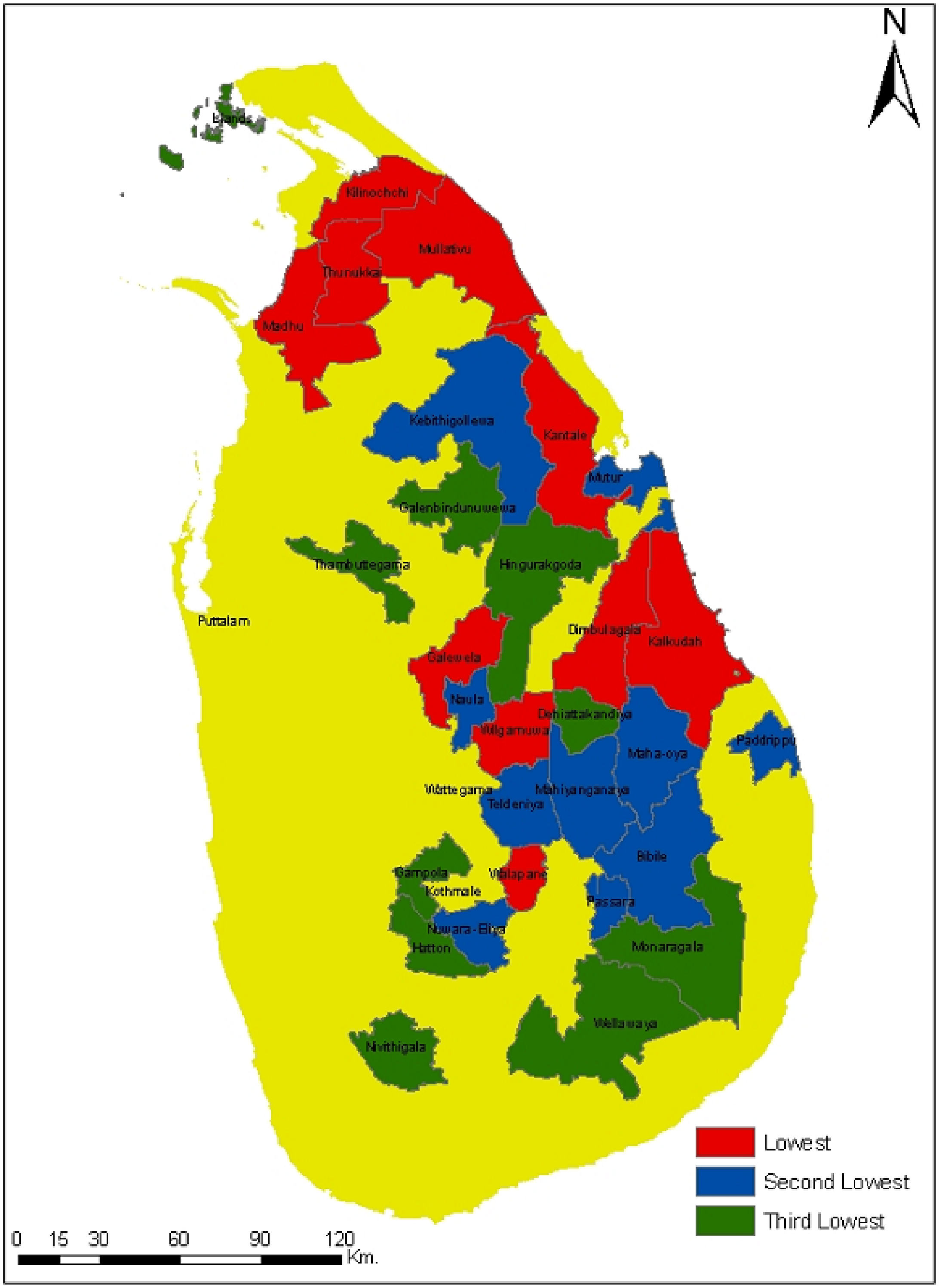
Figure 8 shows the performance of students in mathematics at the GCE O/L examination in 2009. For mathematics, pass rates in national and provincial schools are 74 percent and 44 percent respectively. Compared to the other provinces, the national schools in the Uva and Central provinces show relatively low performance. The ratio of the number of students sitting for the O/L mathematics paper from national and provincial schools is approximately 1:4. This means that 20 percent of the students contribute to a pass rate of 74 percent while 80 percent contribute to a pass rate of 44 percent. Clearly, mathematics education in provincial schools needs to be improved greatly. The same disparity is evident in the performance in science at national and provincial schools (Dissanayake & Sonnadara, 2011).

*Geographical distribution of low performing zones:*

In order to analyze the geographical distribution of the low performing zones, the zones were ranked based on the performance in mathematics at the GCE O/L examination in 2009. Based on this rank, the lowest 30 zones were selected and overlaid on a map of Sri Lanka in three different colour codes to represent the performance level (see Figure 9).

For mathematics, most of the low performing zones are in the Northern, Central, Eastern, Uva and North Central provinces. While all zones in the Western, Southern and North Western provinces seem to perform well, the data reveal that except for Nivitigala all the other zones in the Sabaragamuwa province too perform well. The geographical distribution of the zones clearly indicates that the low performing zones are mainly from conflict affected regions and plantation areas. The fishing communities seem to be performing better than expected. In general, the Western half of Sri Lanka which is economically advanced performs better than the Eastern half.

**Figure 9: The zones with the lowest performance in mathematics at the GCE O/L examination**



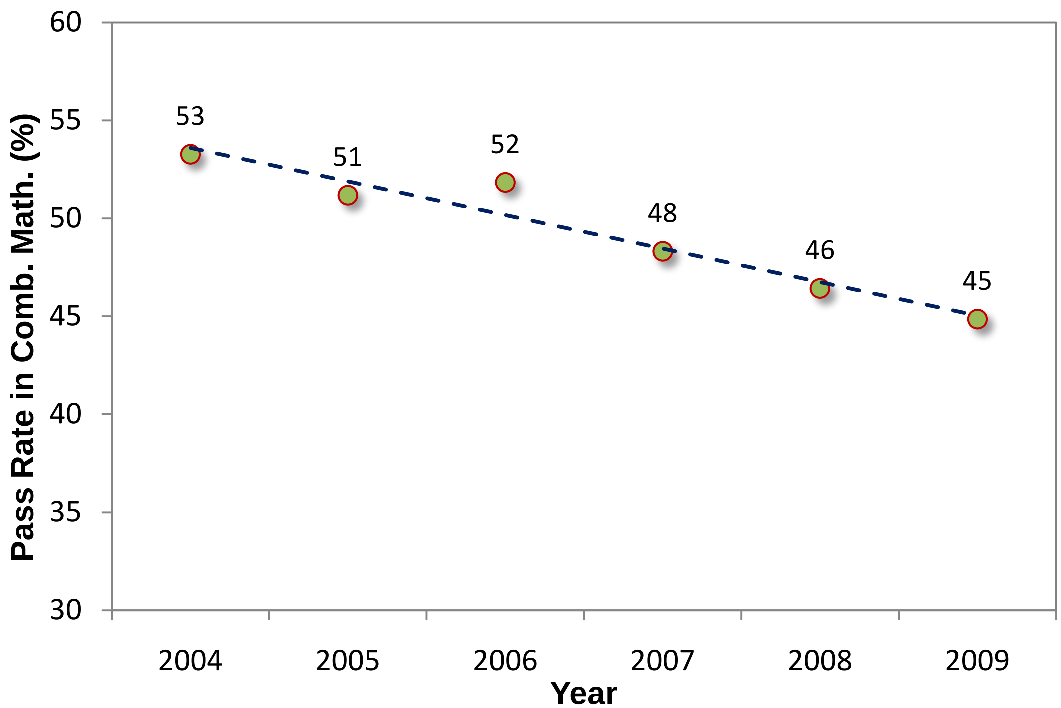

*Source: World Bank estimates, based on Department of Examinations data, 2009*
Note Red: lowest 10%, Blue: lowest 11-20%, Green: lowest 21-30%.

## GCE A/L examination

*Performance variations between the main subjects:*

The school census reveals that there are about 30,000 students following the mathematics curriculum in the Grade 13 classes of government schools. Annually, about 50,000 students sit as school candidates for the GCE A/L physics and chemistry papers while approximately 20,000 sit for the combined mathematics paper.

**Figure 10: Pass rate in Combined Mathematics at the GCE A/L, 2004 – 2009**



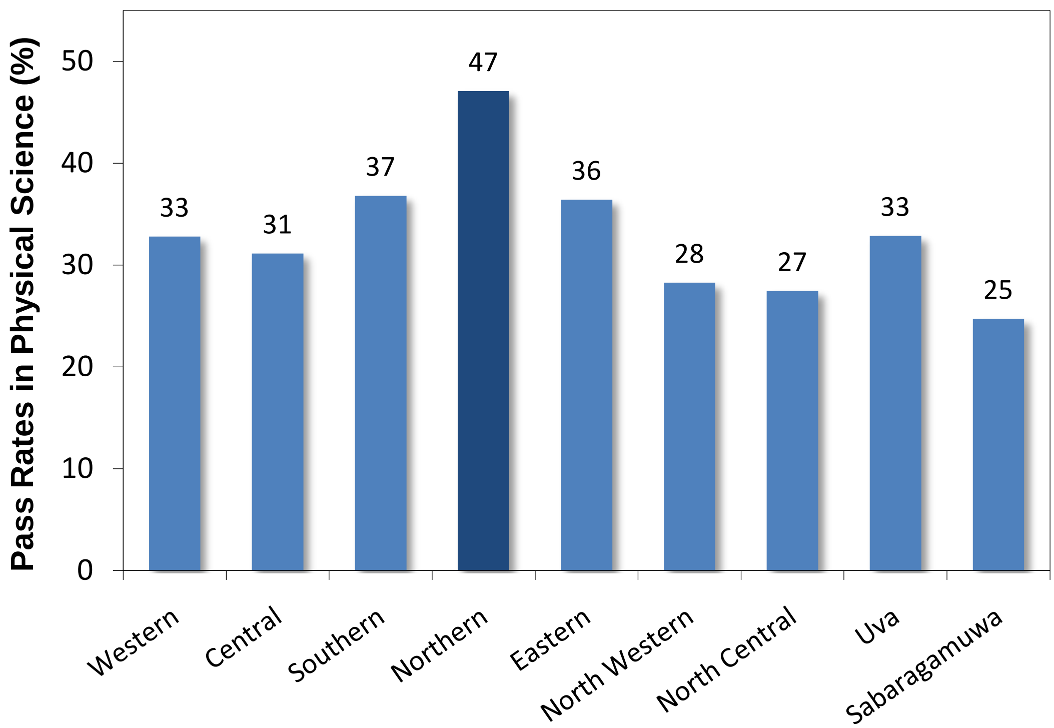

*Source: World Bank estimates, based on Department of Examinations data, 2004-2009*

In Figure 10, the performance of school candidates in combined mathematics at the GCE A/L examination is shown for the years 2004 to 2009. The data show that the pass rates in combined mathematics are low. Pass rates have also decreased by approximately 8 percent between 2004 and 2009. In 2009, while 63 percent and 59 percent of the students passed physics and chemistry respectively at the GCE A/L, only 45 percent passed combined mathematics. Although a credit pass in mathematics at the GCE O/L examination is required to follow the physical science stream at the GCE A/L, the prescribed competency in mathematics may be insufficient to cope with the competency level expected by the GCE A/L combined mathematics syllabus. The present system where all students follow the same mathematics syllabus at the GCE O/L may prevent curriculum developers and teachers from catering to the requirements of students who wish to follow mathematics at the GCE A/L and beyond. This needs to be addressed by policy makers in order to bridge the gap between the GCE O/L and GCE A/L.

*Regional disparities in pass rates:*

In Figure 11, provincial-wise variation in the pass rates of physical science students who sat the GCE A/L examination for the first time in 2009 is shown. The overall pass rate for physical science is at 33 percent. As for biological science (Dissanayake & Sonnadara, 2011), the Northern Province shows the highest pass rate, at 47 percent. However, the number of candidates who sat for the examination from this province is at a very low value perhaps due to the internal displacements caused by the past conflicts. The lowest pass rate of 25% for physical science was reported in Sabaragamuwa.

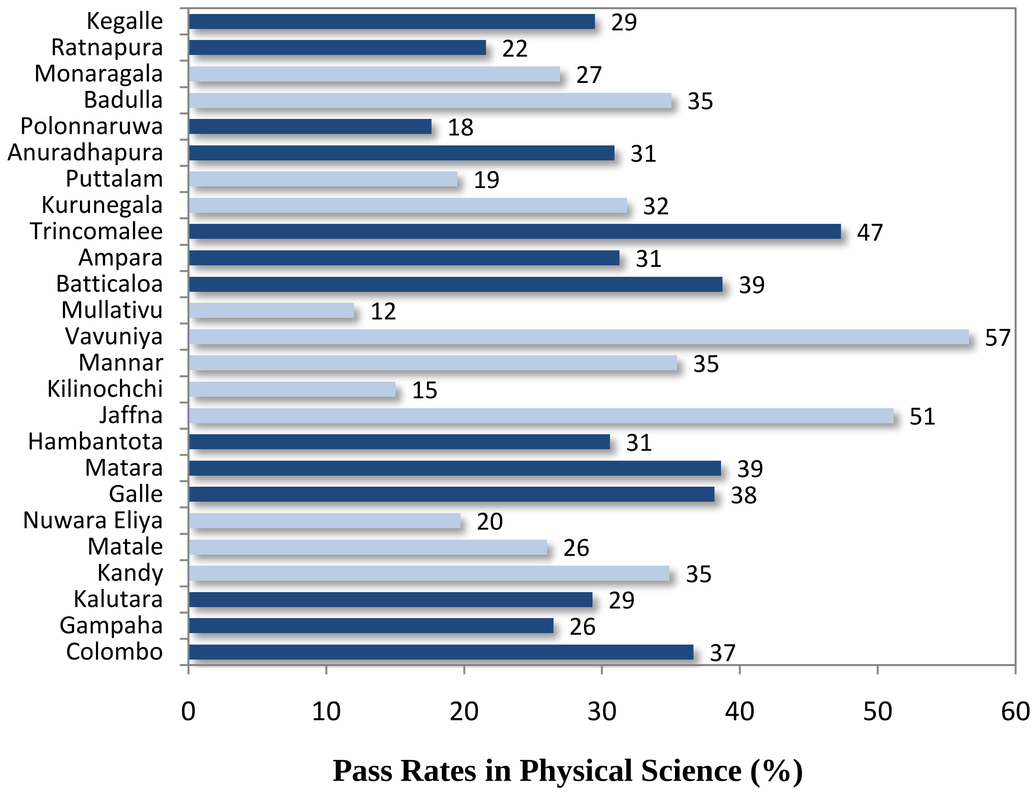
**Figure 11: Provincial performance at the GCE A/L examination, Physical Science**




*Source: World Bank estimates, based on Department of Examinations data, 2009*

At present, the GCE A/L examination pass rates are not desegregated beyond the district level. District level data show further disparities in GCE A/L pass rates (see Figure 12). For physical science, pass rates vary from 12 percent in Mulaitivu to 57 percent in Vavuniya. The data reveal high variations in GCE A/L pass rates at the district level within the Northern province possibly due to low numbers of students sitting for the examination. The Eastern province which also had a number of disruptions due to internal conflicts shows a remarkable comeback.

**Figure 12: Performance at the GCE A/L examination, Physical Science, by District, 2009**



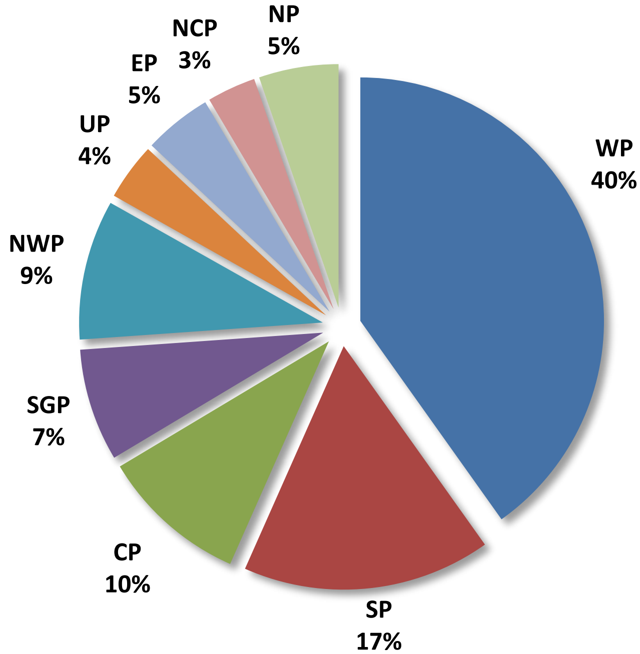

*Source: World Bank estimates, based on Department of Examinations data, 2009*

*Provincial share of students:*

Figure 13 shows the provincial share of physical science students sitting as first time candidates for the GCE A/L examination in 2009.

For physical science, 40 percent of the students are from schools in the Western province. When the numbers from the Western, Southern, Central, Sabaragamuwa and North Western provinces are combined, the share is 83 percent. The better performing provinces are the economically stronger provinces which have better schools. Since the pass rates in these provinces are at a higher level, this phenomenon has a direct bearing on the production of a skilled labour force which can contribute to the enhancement of economically disadvantaged provinces. In addition, this is linked to teacher deployment issues. The smaller the pool of students who qualify in mathematics, the fewer the well qualified teachers in the area to contribute to improving the mathematics standard in the disadvantaged provinces.

**Figure 13: Provincial share of students, Physical Science, 2009**




*Source: World Bank estimates, based on Department of Examinations data, 2009*

## Section two: the national education policy and curriculum reforms

Sri Lankan policy makers since the 1930s have advocated the provision of widespread access to primary and secondary education. This has enabled the country to attain a high level of human development. Realising the importance of science and mathematics education as early as in the 1960s, the then government established the Curriculum Development Centre, mainly to develop the curricula in science and mathematics. In 1972, a common general curriculum was introduced through a major curriculum revision and mathematics was taught to all students in grades 1 to 9. In 1991, the government established the National Education Commission (NEC) which formulated a National Education Policy after wide public consultation and debate. The reforms that were recommended based on this policy were implemented by the government in 1997. These reforms were subjected to a series of evaluation studies and in 2003 a new set of reforms were proposed and implemented from 2007 (NEC, 2003).

The actions recommended by the Presidential Task Force in 1997 for primary education based on the proposals of the NEC included the following: an integrated curriculum incorporating the Mother Tongue, Religion, Mathematics and Environment Related Activities, a child centred approach, a learning teaching process based on guided play, activity and desk work, identification of entry level competencies and essential learning competencies, and continuous assessment throughout the learning teaching process (NEC, 2003).

These reforms were carried out successfully and the recommendations of the NEC in 2003 were that the curriculum developed in 1997 should be retained for primary education, but that the training of mathematics should be strengthened to raise the levels of attainment. The education reforms proposed in 1997 for junior secondary education were in contrast to the primary education reforms, weak, both conceptually and implementation-wise, lacking clear direction and cohesion. Several problems associated with mathematics education at the secondary level were identified and new proposals were put forward to improve the quality of mathematics education at the junior secondary level (NEC, 2003).

**Problems identified in relation to mathematics education under the 1997 reforms**

1. The education system does not produce young people with basic mathematics skills and competencies required by the world of work.
2. The curriculum has not been modernized to suit the needs of the modern world.
3. There is a dearth of mathematics qualified personnel in the job market.
4. Modern techniques are not used in the learning teaching process.
5. Teacher guides are neither comprehensive nor adequate.
6. Teachers are neither adequately trained nor motivated.
7. Education software and other essential teaching materials are not available.
8. Textbooks are scarce or not available.
9. Monitoring mechanisms are not effective.
10. Mathematics education is too theoretical with little emphasis on applications.

**The NEC proposals to improve the quality of mathematics education**

1. Extensive revision or re-formulation of the curricula.
2. Modern learning-teaching methodologies such as an activity based student centred approach. Use of IT as a tool in the learning teaching process.
3. Preparation of textbooks and teacher guides based on the curricula.
4. Both pre-service and in-service teacher training in mathematics strengthened.
5. Promotion and popularization of mathematics.

*Source: NEC (2003)*

In 2007, a competency based learning teaching assessment model was adopted to address the issue that students were unable to demonstrate acceptable levels of achievement in applying their learning to everyday situations. It was found that their skills in open ended problem solving and decision making were weak and that few were able to demonstrate their ability to use higher order skills.

The main aim of the mathematics curriculum under these reforms was to develop individuals who are able to think mathematically, and apply mathematical knowledge effectively and responsibly in solving problems and making decisions.

Two studies were carried out on the curricula introduced in grades 6 and 10 in 2007 (NIE, 2008), and in grades 7 and 11 in 2008 (NIE, 2009). Several shortcomings in the design, planning, development and implementation of the curricula have been highlighted in these two reports. Some of the shortcomings highlighted are: (a) the new curriculum reforms were not based on research findings or weaknesses in the preceding curriculum; (b) no proper pre-testing was carried out with regard to appropriateness; (c) there is no horizontal integration of different subjects; (d) only the 5E model is used as the learning methodology; (f) dissemination and publicizing of ideas relevant to the new curriculum were not adequate; (g) the understanding of the implementation of the curriculum among teachers was inadequate; (h) there is no systematic monitoring to identify shortcomings in the curriculum.

Focus group discussions with teachers too revealed various problems in the implementation of the new curriculum. Teachers felt that the training they had received on implementing the curriculum was inadequate, that there was insufficient time allocated for all the activities proposed in the Teacher's Instructional Manuals and that the 5E method is not the most appropriate teaching strategy in all situations.

## Section three: mathematics standards

International mathematics education focuses on developing individuals with the reasoning abilities and communication skills required to solve everyday problems, by integrating the traditional content of mathematics to make meaning of the real world.

Many leading international educational jurisdictions recognize the ***Standards for School Mathematics*** developed by the National Council of Teachers of Mathematics (NCTM) as a global benchmark (McCaul, 2007). NCTM defines 'standards' as the mathematical content and processes that students should know and be able to use as they progress through school. They set out five content standards which describe explicitly the five strands of content that students should learn, and five process standards highlighting the ways of acquiring and applying content knowledge (see Table 1).

**Table 1: Comparison of the NCTM standards and Sri Lankan standards**

| NCTM content standards | Sri Lankan content standards |
|---|---|
| Number and Operations | Numbers |
| Measurement | Measurement |
| Geometry | Geometry |
| Algebra | Algebra |
| Data Analysis and Probability | Statistics |
| | Sets and Probability |
| | |
| NCTM process standards | Sri Lankan process standards |
| Communication | Communication |
| Representation | (Knowledge and ) Skills |
| Connections | Relationships |
| Reasoning and Proof | Reasoning |
| Problem Solving | Problem Solving |

*Source: National Council of Teachers of Mathematics (www.nctm.org) & National Institute of Education, Sri Lanka.*

Table 1 reflects that the Sri Lankan content standards and process standards are aligned with international trends.

The **Trends in International Mathematics and Science Study** (TIMSS) is a continuing cycle of international mathematics and science assessments conducted every four years for fourth and eighth grade students. It assesses achievement in countries around the world and collects information on the educational contexts for learning mathematics and science. TIMSS data have been collected in 1995, 1999, 2003, and 2007.

In the years 1999, 2003 and 2007, the Asian Pacific countries, Singapore, the Republic of Korea, Chinese Taipei, Hong Kong and Japan have consistently had the highest average performance in mathematics amongst grade 8 students. In 2003, Singapore was the top performing country at both the fourth and eighth grades, having significantly higher average achievement in mathematics than the rest of the participating countries. In 2007, there was a significant gap between the average achievement in mathematics at grade 8 of the above five Asian Pacific countries and the rest of the participating countries. In the same year, the achievement of 40 to 45 percent of grade 8 students in China Taipei, Korea and Singapore were at or above the Advanced International Benchmark, which represents fluency on items involving the most complex topics and reasoning skills. The median percentage of students reaching this Benchmark that year was 2 percent.

Factors associated with higher achievement in mathematics include: (i) speaking the language of the test at home, (ii) higher levels of parents' education, (iii) positive attitude towards learning mathematics (iv) higher educational expectations, (v) more educational resources and books in the home, and (vi) attending a school where (a) satisfactory working conditions and adequate resources are provided, (b) there are less attendance problems and fewer students from economically disadvantaged homes, and (c) principals and teachers have a positive view of the school climate.

*Source: Mullis et. al. (2008).*

## Section four: mathematics curriculum and teaching strategy

The primary and secondary school mathematics curriculum of Sri Lanka is developed by the Department of Mathematics, Faculty of Science and Technology of the National Institute of Education (NIE), Sri Lanka.

### Primary Education (Grades 1 to 5)

The mathematics Teacher's Instructional Manuals (TIMs) for the primary education cycle contain ten common competencies to be developed in key stage 1 (Grades 1 and 2), key stage 2 (Grades 3 and 4) and key stage 3 (Grade 5). The TIMs also specify entry level competencies and essential learning competencies for each grade, the subject content and the learning teaching methodology. An assessment report card with the essential learning competencies is provided at the back of the TIMs. The syllabus has a spiral approach and concepts are introduced in different grades with increasing depth. Textbooks which are aligned with the TIMs are provided to students in Grades 3 to 5.

Table 2 compares the primary mathematics content standards of Sri Lanka with those of Singapore (MOE, 2007) which has scored well on recent international assessment studies such as Trends in Mathematics and Science Study (TIMSS) and Programme of International Student Assessment (PISA).

**Table 2: Primary Content Standards – A Comparison**

<table>
<tr><th colspan="2">Sri Lanka</th><th colspan="2">Singapore</th></tr>
<tr><td rowspan="2">Grades 1 and 2</td><td rowspan="2">Numbers,<br>Measurements,<br>Money,<br>Shapes and Space</td><td>Grade 1</td><td>Whole Numbers<br>Measurements<br>Geometry<br>Data Analysis</td></tr>
<tr><td>Grade 2</td><td>Grade 1 Standards & Fractions</td></tr>
<tr><td rowspan="3">Grades 3, 4 and 5</td><td rowspan="3">Numbers,<br>Operations,<br>Measurements,<br>Money,<br>Shapes and Space<br>Manipulation of Data</td><td>Grade 3</td><td>Same as Grade 2</td></tr>
<tr><td>Grade 4</td><td>Grade 3 Standards & Decimals</td></tr>
<tr><td>Grade 5</td><td>Grade 4 Standards & Percentages, Ratios</td></tr>
</table>

*Source: National Institute of Education, Sri Lanka & Ministry of Education, Singapore*

The content standards of the Sri Lankan syllabi and the Singapore syllabi are similar. However, Sri Lanka introduces data analysis only in grade 3, whereas Singapore introduces it in grade 1. Singapore also introduces ratios and percentages in grade 5, while Sri Lanka introduces these concepts only in grades 6 and 7 respectively.

Three hours and thirty minutes are allocated per week for mathematics in key stage 1, while 5 hours are allocated per week for mathematics in key stages 2 and 3. The learning teaching process in the primary education cycle involves guided play, activity and desk work. In key stage 1, greater emphasis is placed on guided play. Equal emphasis is given to the three processes in key stage 2, and in key stage 3, greater emphasis is placed on activity and desk work. Teachers are encouraged to use mathematics activity rooms, competitions, projects, exhibitions etc., to kindle the interest of students in mathematics and develop their knowledge and skills.

Studies carried out by the Sri Lanka Association for the Advancement of Education (SLAAED) and the National Education Research and Evaluation Centre (NEREC) have revealed that the reforms in 1997 have had a positive effect on the quality of primary education (SLAAED, 2000, NEREC, 2002)

### Junior Secondary Education (Grades 6 to 11)

A description of the aims of learning mathematics, the learning teaching process, the subject content, competencies, competency levels, activity continuum and assessment criteria is provided in the TIMs of grades 6 to 11. There are a common set of aims of learning mathematics and 31 common competencies specified for grades 6 to 11. Under the competencies, competency levels as well as subject content and learning outcomes are specified for each grade.

A study carried out on the implementation of the mathematics and science curricula in grades 6 and 10 revealed that the curriculum strands and general aims correspond to international standards (McCaul, 2007). However the study also highlighted several shortcomings in the TIMs. These are common to the grades 7 to 9 and grade 11 TIMs as well.

**Shortcomings in the Mathematics TIMs – Junior Secondary Education**

1. Learning outcomes are not included for the process strands of communication, relationships, reasoning and problem solving.
2. The TIM activities are limited to focusing on basic concepts and mathematical skills and do not engage students in applying their learning to everyday problems and situations.
3. Instructions for activities provide only general and not specific criteria for assessing students during each activity.
4. The collective total of the areas identified for assessment and evaluation in the activities do not provide a balanced range for assessing the competencies set out for the course.
5. The use of technologies such as hand calculators is limited.
6. The TIMs provide activities to fill the allocated number of periods, but little guidance is given for adjustments to be made to accommodate student needs or time constraints.

*Source: McCaul (2007)*

Mathematics is taught in the classroom through a series of activities. All activities are described in step-by-step detail, follow the same format and prescribe the same teaching strategy. The activities are designed in a sequence according to the 5E learning cycle of engagement, explanation, exploration, elaboration and evaluation.

Focus group discussions with teachers revealed that the syllabus cannot be covered if every lesson is taught according to the 5E model. The term papers set by the provinces on the other hand have a compulsory question based on an activity in the TIM. This compels the teacher to use only the activities specified in the TIM in their lessons. Teachers are not allowed the freedom to develop their own lessons or to use different teaching strategies.

McCaul (2007) in his report states that the TIMs do not provide an organizing structure of how content and process learning outcomes are to be balanced. Concepts and mathematical skills are emphasized over other process standards. The activities require students to engage in problem solving, classifying data and communicating results. However specific expectations for process skills upon which teachers can base assessment of learning in these areas are not provided. Little emphasis is placed on the development of skills in the relationships, reasoning and problem solving standards. The TIMs also do not provide opportunities for open ended and creative problem solving.

Thus, although the mathematics curriculum specifies skills, communication, relationships, reasoning and problem solving as process standards, little emphasis has been placed on developing the full spectrum of process skills that are specified, in particular, relationships, reasoning and problem solving.

The Singapore mathematics syllabus emphasizes Mathematics Problem Solving as the critical focus of its mathematics courses. The development of this ability is dependent on concepts, mathematical skills, processes, attitudes and metacognition. The syllabus provides clear direction on how these components should be integrated into the teaching of mathematics. (Annex 1, Singapore Syllabus). Sri Lanka should also adopt these strategies to enhance the problem solving skills of students.

### Textbooks:

The Education Publications Department (EPD) is responsible for the production and distribution of textbooks.

In the Sri Lankan context, since teacher deployment is a serious issue and many schools particularly in the rural areas face severe shortages in good mathematics teachers, it is imperative that the country provides high quality textbooks to aid students in their learning.

The government provides mathematics textbooks for students in grades 6 to 11. The textbooks are based on the syllabi provided by the NIE and are written by a panel whose names are listed within the textbook. Final evaluation is done by a university lecturer. Although the textbooks provided under the new programme have gone through several cycles of revision, it is regrettable that they still contain many factual, conceptual, grammatical and typographical errors. Several of the exercise problems in the textbooks too contain errors. The presentation in particular needs to be improved.

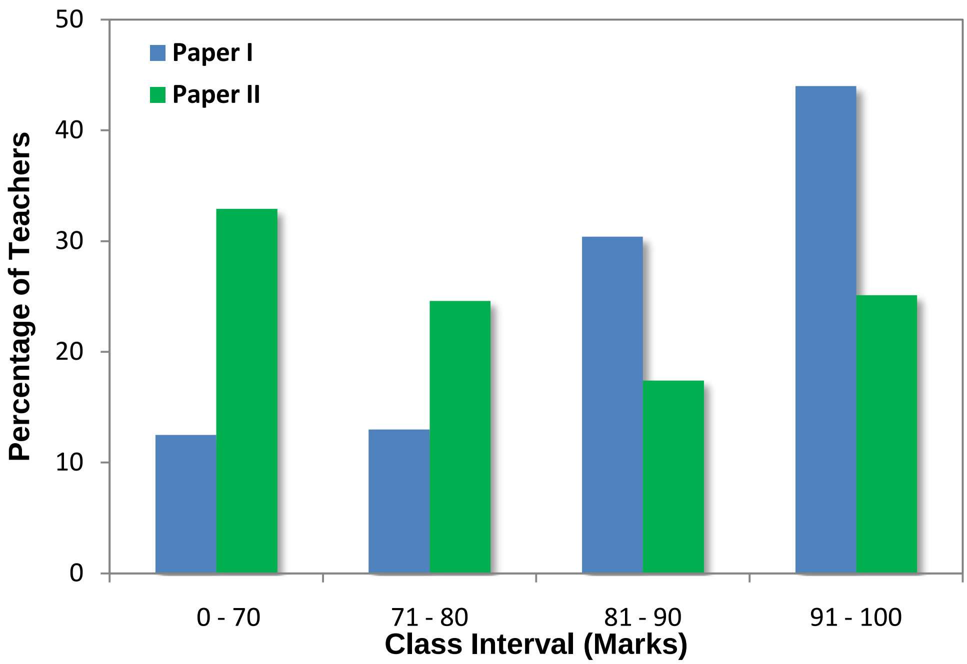
It is encouraging though to note that during the last year, the EPD has taken several steps to improve the quality of the textbooks.

## Teacher Recruitment, Deployment and Training:

Teachers with sound mathematics knowledge and effective teaching practices are essential for imparting excellent mathematics education. In Sri Lanka, 50 percent of the students consistently fail in mathematics at the GCE O/L examination. One of the chief causes for this is the quality of the mathematics teachers in the school system. There are approximately 1,600 Sinhala medium and 800 Tamil medium teachers in the system with appointments for other subjects who teach mathematics in the secondary education cycle.

In 2008, the NIE conducted a study to assess the mathematics knowledge of teachers in schools where students score less than 30 percent in the GCE O/L mathematics paper. 172 teachers participated in the study. A question paper containing 9 questions on the themes measurement and algebra was given. An analysis of the marks obtained by the teachers revealed that 36 percent of teachers from the Western province and 51 percent of the teachers from the other provinces scored less than or equal to 5 marks out of 10 (NIE, 2008).

**Figure 14: Performance of O/L Mathematics Teachers**




*Source: Department of Examinations, 2010*

In another study conducted by the DOE in 2010 to determine the causes for the poor performance in mathematics at the GCE O/L examination, 207 teachers who had applied for paper marking were selected and given a question paper similar to the GCE O/L mathematics paper (DOE, 2010). An analysis of the marks obtained is represented in Figure 14.

The data shows that although most teachers performed well in paper I, this is not the case for paper II. Paper II tests higher order skills and 50 percent of the paper contains problems on algebra and geometry. Only 42 percent of the teachers were able to score over 80 percent on paper II. Question by question analysis revealed that teachers' performance was poorest on geometry questions. The same weakness is reflected in students' performance at the GCE O/L examination. The study also revealed that mathematics teachers with distance training performed the poorest, while NCOE trained teachers performed the best.

These two studies reflect the urgent need for a comprehensive teacher development programme to enhance the knowledge and skills of mathematics teachers.

### The GCE O/L Examination:

A pass in mathematics at the GCE O/L examination is compulsory to qualify for the GCE A/L. The data given in Table 3 show the performance of students in mathematics at the GCE O/L examination held in 2007, 2008 and 2009 (DOE, 2008 - 2010).

**Table 3: Performance in mathematics at the GCE O/L examination**

| Class Interval | Percentage | | |
|---|---|---|---|
| | *2007* | *2008* | *2009* |
| 90-100 | 0.29 | 1.68 | 0.77 |
| 80-89 | 2.22 | 4.17 | 2.67 |
| 70-79 | 5.70 | 5.75 | 4.25 |
| 60-69 | 5.36 | 6.84 | 5.14 |
| 50-59 | 5.37 | 10.91 | 6.98 |
| 40-49 | 10.75 | 7.64 | 8.08 |
| **30-39** | **21.30** | **13.84** | **13.15** |
| **20-29** | **10.83** | **12.80** | **16.08** |
| **10-19** | **16.12** | **17.48** | **19.12** |
| **0-9** | **22.05** | **18.90** | **23.02** |

*Source: Control Chief Examiners Meeting Reports, Department of Examinations, 2008-2010*

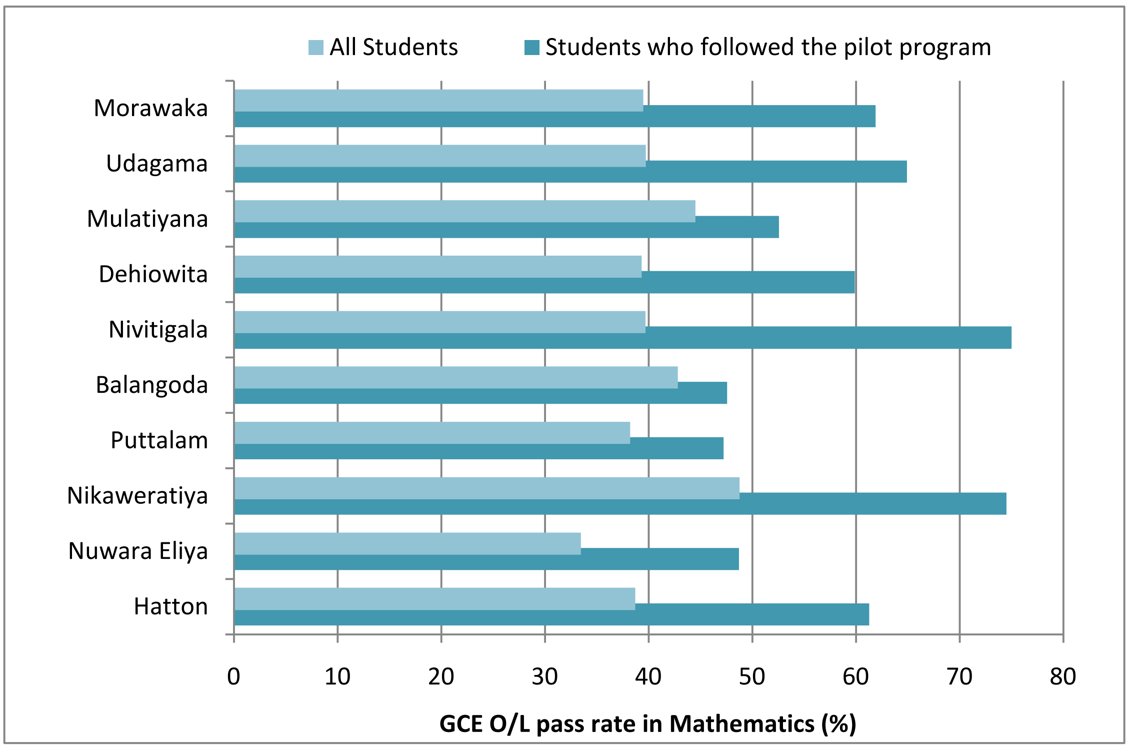
The pass mark at the GCE O/L examination is 35 percent. During the years 2007 to 2009, approximately 60 percent, 55 percent and 65 percent respectively of students obtained a mark below 35 percent in mathematics[2].

[2] In 2008, the initial mathematics paper was cancelled and a repeat paper, similar to the cancelled paper was given. This may be the reason why the number who scored less than 35 percent is significantly less in 2008, than in 2007 and 2009.

**Case Study: Remedial Education Programme on Mathematics, Grade 11**

In 2007, the Ministry of Education initiated a remedial education programme to improve students' performance in mathematics at the GCE O/L examination. Students whose grade 10 final term mathematics mark is below 40 percent are selected to participate in the programme annually from two zones per province. Approximately 300 students per zone (total of about 6000) participate in the programme annually. The programme is conducted at selected centres across the country on 25 Saturdays. Teachers who are chosen by the MOE act as resource personnel. Each student who participates begins at his/her level. Concepts are taught and then students are given problems to solve in increasing levels of difficulty. A workbook has been developed by the MOE for this purpose.

The performance in mathematics at the 2007 GCE O/L examination, of students who followed the programme is given below for 10 selected zones, together with the performance of all students in the zone. The data clearly shows that students who followed the remedial programme have performed well, reflecting the success of the remedial programme, since the students who were selected for this program were the weak students who were likely to fail mathematics at the O/L examination.




*Source: Ministry of Education*

There are various factors contributing to the poor performance in mathematics at the GCE O/L examination. As indicated in the previous section, the subject knowledge of teachers is one of the major contributing factors. Apart from this, students passing from one grade to another without gaining the knowledge and skills that are essential to cope with the work in the higher grade, is another contributing factor.

In Sri Lanka, mathematics education is compulsory up to grade 11 and is commonly termed "mathematics for all". Mathematics education up to grade 9 focuses on developing the basic skills required to function effectively in daily life, as well as on enhancing the analytical abilities of students. Also, students in the secondary level are expected to be led away from primary level methodologies where mathematical concepts are introduced with concrete examples and pictures, to a logical understanding of abstract mathematical concepts. The assessment of achievement at this stage is school based. This approach agrees and supports the `mathematics for all' concept up to grade 9. However, in grades 10 and 11, more emphasis is given to the basics of higher mathematics including algebra and geometry; i.e., all students in this age group are compelled to learn mathematics as a 'subject' distorting the concept of 'mathematics for all' to a concept of 'same mathematics for all' (NIE, 2006). This is also a major contributing factor for the high failure rate in mathematics at the GCE O/L examination.

In the past, criticism has been levelled against two aspects of the GCE O/L mathematics paper, namely the high rate of failure and the validity of the "A" grade. A fair percentage of students who receive an "A" grade for the GCE O/L mathematics paper fail the GCE A/Ls. The structure of the new syllabus GCE O/L mathematics paper introduced in 2008 was designed with the intention of addressing both these concerns.

Table 4 gives the percentage of problems on each content strand contained in the GCE O/L mathematics paper.

**Table 4: Percentage of problems on each strand contained in the GCE O/L mathematics paper**

| Content Strand | Percentage |
|---|---|
| Numbers | 15% |
| Measurements | 15% |
| Algebra | 25% |
| Geometry | 25% |
| Statistics | 10% |
| Sets and Probability | 10% |

*Source: World Bank estimates based on the GCE O/L Mathematics paper, 2009*

In the new format, both Paper I and Paper II carry equal weight. Paper I focuses mainly on the strands numbers, measurements, statistics, sets and probability. This paper aims at testing only the basics and a student who wishes to follow an A/L subject stream which requires only a pass in mathematics could do so by performing well in Paper I. It was with the intention of addressing the high failure rate in mathematics that Paper I was designed in this manner.

In Paper II, more emphasis is given to algebra and geometry. This paper mainly tests medium and higher order knowledge and skills. Of the 12 questions, 6 are on algebra and geometry. Students have to answer 5 questions from each of the parts A and B. During the past three years, the 3 algebra questions have appeared in Part A, and the three geometry questions in Part B. Thus students are compelled to answer at least 2 algebra questions and 2 geometry questions. Hence, to obtain an A grade in mathematics, a student would have to perform well in these two areas which tests students' knowledge in higher mathematics. It was with the intention of addressing the issue of the validity of the "A" that Paper II was designed in this manner.

An analysis of the GCE O/L mathematics papers carried out by the Research and Development branch of the Department of Examination reveals that in the years 2008 and 2009, since the new curriculum was introduced, the performance of students in geometry has been extremely poor. For example, in year 2009, questions 10 and 11 (which were two of the geometry questions) were selected by less than 50 percent and 40 percent of the students respectively. Over 65 percent and 85 percent respectively of those who attempted these questions scored less than 25 out of a total of 100. Similar trends were seen in 2008 too.

Thus it is clear that despite the structure of the examination paper being changed in an attempt to address the two issues of the high failure rate and the validity of the "A" grade, these problems still persist.

### Senior Secondary Education (Grades 12 and 13)

There are three mathematics courses offered by GCE A/L students. All Physical Science students offer combined mathematics. Higher mathematics is offered on average by less than 10 Physical Science students. Mathematics is offered on average by less than 75 Arts students.

Mathematics and science at the senior secondary education level are available at only 600 schools which account for about 25 percent of the schools with GCE A/L classes. Recognizing the need to expand science and mathematics education, the NEC proposed that A/L science and mathematics streams be introduced in 1,745 type 1C schools across the island in a phased programme, to provide access to children from rural areas (NEC, 2003).

Despite the NEC proposals, little has been done to encourage students to select mathematics as a subject at the A/Ls or to promote mathematics in schools. The data given in Table 5 shows that the number of school candidates offering combined mathematics as a subject at the GCE A/L has not increased during the past 6 years. The data also reveals the decreasing trend in combined mathematics pass rates (53 percent in 2004 to 45 percent in 2009). Measures should be taken to curb this trend.

**Table 5: Performance of school candidates in combined mathematics at the GCE A/L**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| **Number sat** | 21,209 | 20,737 | 21,399 | 20,160 | 21,273 | 21,297 |
| **Pass Rate** | 53.3% | 51.2% | 51.8% | 48.3% | 46.4% | 44.9% |

*Source: World Bank estimates based on Department of Examinations data, 2004-2009*

***Curriculum:***

The syllabi and TIMs for the senior secondary education cycle are prepared by the NIE in consultation with university academic staff. A competency based curriculum was introduced in 2009. The 5E learning teaching model is advocated in the TIMs.

Focus group discussions with A/L mathematics teachers revealed that the training provided by the NIE is irrelevant and confusing. Teachers stated that the NIE used the services of university academic staff who are not involved in curriculum development or paper setting/marking to provide the training. This resulted in the training consisting of a series of lectures on mathematical content. No teaching strategies or instructions on the implementation of the curriculum were provided. Teachers also stated that although the syllabi are competency based and the 5E model of teaching is advocated, due to lack of time, most adopt lecture style teaching.

There are no textbooks provided by the government for A/L mathematics. The EPD has translated several English medium mathematics textbooks which have assisted students greatly and this practice should be continued. The EPD need not venture into producing their own text books for the A/Ls.

# Section five: pathways to the future

The information provided in this paper demonstrates that the government of Sri Lanka recognizes the need to improve the quality of mathematics education in schools. Several initiatives have been taken in this direction. Studies have been conducted on the implemented reforms and efforts have been made to address the shortcomings. Some of these shortcomings have been highlighted in the preceding sections. Proposals to address them are given below.

## Proposals for improving mathematics education

Although various attempts have been made in the past to address the issue of the high failure rate in mathematics at the GCE O/L examination, none have been successful. The cognitive capacities and the mental development of students vary. This needs to be taken into consideration when curricula are being formulated. Countries such as Singapore and the U.K. address this by providing different mathematics syllabi and examination papers to cater to the varying needs and abilities of students. In Sri Lanka, some of the GCE A/L subject streams do not require the level of knowledge and skills in higher mathematics that is expected from the present GCE O/L curriculum. On the other hand, obtaining an A or B grade in mathematics at the GCE O/L examination does not guarantee that students who follow A/L subject streams which require a high level of mathematical knowledge and skills will perform well at the senior secondary level. These two issues can only be addressed successfully if Sri Lanka too adopts the practice of countries such as Singapore and the U.K and introduces different mathematics syllabi and examinations to cater to the needs of the different groups of students, namely those who wish to pursue A/L subjects that require a high level of mathematical knowledge and skills and those who only need a practical knowledge of mathematics.

The reforms introduced in 2007 will be continued until 2014. Despite the fact that it is four years since the implementation of the competency based curriculum, many teachers still do not seem to have a clear understanding of the expectations of the curriculum, and hence awareness programmes on the objectives of the curriculum should be conducted. Since there is no systematic monitoring to identify shortcomings in the curriculum, an on-going monitoring programme needs to be designed and implemented to ascertain whether the objectives of the curriculum are met. Training on different teaching strategies needs to be provided and teachers need to be encouraged to use their experience and judgement to select the most appropriate methods to motivate students and impart knowledge and skills. It is detrimental to restrict teaching to just one strategy as is done at present.

Research findings on the implementation of the mathematics and science curricula in grades 6 and 10 have highlighted several shortcomings in the TIMs (McCaul, 2007). To overcome these shortcomings, learning outcomes need to be provided not only for the content standards but for the process standards as well. Activities should include the process standards reasoning and problem solving, and clear guidelines need to be provided on how the process standards are to be assessed. Attention needs also to be paid to the horizontal integration of subjects and the use of technology. Teachers need to be encouraged to develop their own lesson plans and to use different teaching strategies. In particular, strategies specified in the Singapore syllabus need to be adopted to emphasize problem solving.

To ensure that students are provided with quality textbooks, the Education Publications Department needs to invest in hiring a team of competent, qualified writers. Writers need to be made aware of the aims of the competency based curriculum so that the textbooks are aligned with the curriculum. To increase accountability, the chapters written by each author should be stated in the textbook. Final evaluation of the textbooks needs to be undertaken by at least two subject experts.

Teachers play one of the most important roles in providing students with a high quality mathematics education. Therefore it is essential to ensure that all mathematics teachers are subject-competent and have sound teaching practices. Since there are many teachers in the system without the required mathematics training, it is of vital importance to initiate a comprehensive teacher development programme that will provide teachers with both the required subject knowledge and training in good teaching practices. The advice and support of university academics and mathematics educators should be obtained in this regard.

Although there is a dearth of mathematics qualified persons in the job market, little attempt has been made to promote mathematics in schools. The number of school candidates offering combined mathematics as a GCE A/L subject has been approximately 21,000 from 2004 to 2009. Mathematics should be promoted in schools through events such as math days, national mathematics competitions and mathematics camps.

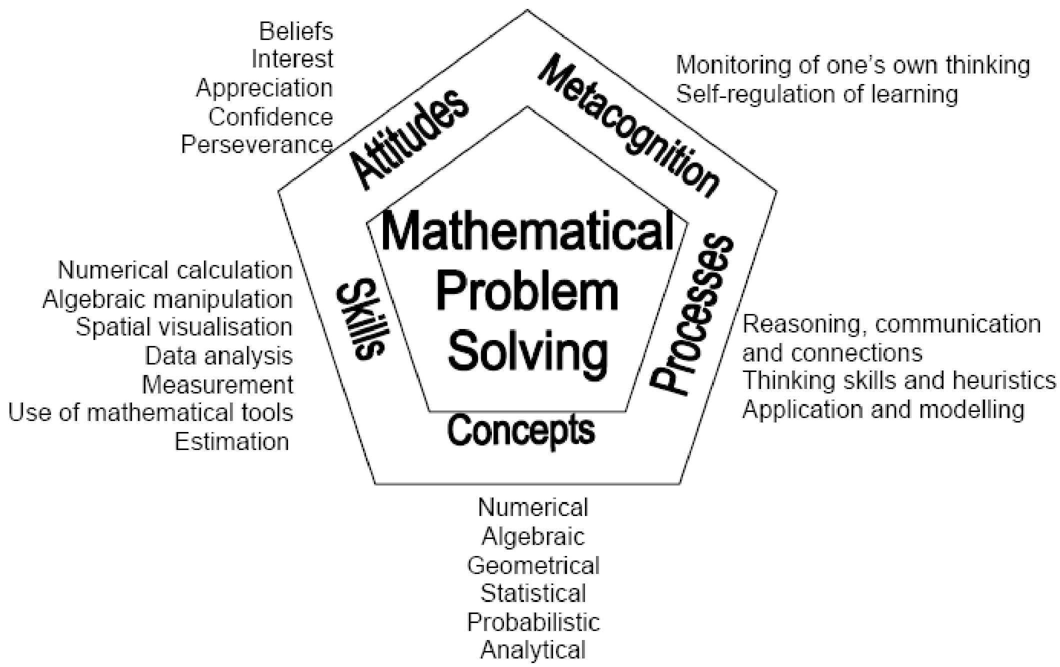
Teacher development programmes conducted by the NIE for GCE A/L mathematics teachers need to improve. The NIE should liaise with university academic staff involved in curriculum development and teacher education to draw up a meaningful teacher development programme. Since there are only a few good mathematics textbooks available for GCE A/L students in the Sinhala and Tamil mediums, EPD should continue its practice of translating English medium mathematics textbooks which are recommended by the curriculum developers.

# ANNEX ONE

## SINGAPORE MATHEMATICS FRAMEWORK

http://www.MOE.gov.sg/education/syllabuses/maths-secondary

This framework shows the underlying principles of an effective mathematics programme that is applicable to all levels, from the primary to A-levels. It sets the direction for the teaching, learning, and assessment of mathematics.




Mathematical problem solving is central to mathematics learning. It involves the acquisition and application of mathematics concepts and skills in a wide range of situations, including non-routine, open-ended and real-world problems.

The development of mathematical problem solving ability is dependent on five inter-related components, namely, *Concepts*, *Skills*, *Processes*, *Attitudes* and *Metacognition*.

### CONCEPTS

**Mathematical concepts** cover numerical, algebraic, geometrical, statistical, probabilistic, and analytical concepts. Students should develop and explore the mathematics ideas in depth, and see that mathematics is an integrated whole, not merely isolated pieces of knowledge. They should be given a variety of learning experiences to help them develop a deep understanding of mathematical concepts, and to make sense of various mathematical ideas, as well as their connections and applications, in order to participate actively in learning mathematics and to become more confident in exploring and applying mathematics.

The use of manipulatives (concrete materials), practical work, and use of technological aids should be part of the learning experiences of the students.

## SKILLS

**Mathematical skills** include procedural skills for numerical calculation, algebraic manipulation, spatial visualisation, data analysis, measurement, use of mathematical tools, and estimation. The development of skill proficiencies in students is essential in the learning and application of mathematics. Although students should become competent in the various mathematical skills, over-emphasising procedural skills without understanding the underlying mathematical principles should be avoided. Skill proficiencies include the ability to use technology confidently, where appropriate, for exploration and problem solving. It is important also to incorporate the use of thinking skills and heuristics in the process of the development of skills proficiencies.

## PROCESSES

**Mathematical processes** refer to the knowledge skills (or process skills) involved in the process of acquiring and applying mathematical knowledge. This includes reasoning, communication and connections, thinking skills and heuristics, and application and modelling.

*Reasoning, communication and connections:*
Mathematical reasoning refers to the ability to analyse mathematical situations and construct logical arguments. It is a habit of mind that can be developed through the applications of mathematics in different contexts. Communication refers to the ability to use mathematical language to express mathematical ideas and arguments precisely, concisely and logically. It helps students develop their own understanding of mathematics and sharpen their mathematical thinking. Connections refer to the ability to see and make linkages among mathematical ideas, between mathematics and other subjects, and between mathematics and everyday life. This helps students make sense of what they learn in mathematics. Mathematical reasoning, communication and connections should pervade all levels of mathematics learning, from the primary to A-levels.

*Thinking skills and heuristics:*
Students should use various thinking skills and heuristics to help them solve mathematical problems. Thinking skills are skills that can be used in a thinking process, such as classifying, comparing, sequencing, analysing parts and wholes, identifying patterns and relationships, induction, deduction and spatial visualization. Some examples of heuristics are listed below and grouped in four categories according to how they are used:

- To give a representation,
  e.g. draw a diagram, make a list, use equations
- To make a calculated guess,
  e.g. guess and check, look for patterns, make suppositions
- To go through the process,
  e.g. act it out, work backwards, before-after
- To change the problem,
  e.g. restate the problem, simplify the problem, solve part of the problem

*Applications and modelling:*

Applications and modelling play a vital role in the development of mathematical understanding and competencies. It is important that students apply mathematical problem-solving skills and reasoning skills to tackle a variety of problems, including real-world problems. Mathematical modelling is the process of formulating and improving a mathematical model to represent and solve real-world problems. Through mathematical modelling, students learn to use a variety of representations of data, and to select and apply appropriate mathematical methods and tools in solving real-world problems. The opportunity to deal with empirical data and use mathematical tools for data analysis should be part of the learning at all levels.

## ATTITUDES

**Attitudes** refer to the affective aspects of mathematics learning such as:

- Beliefs about mathematics and its usefulness
- Interest and enjoyment in learning mathematics
- Appreciation of the beauty and power of mathematics
- Confidence in using mathematics
- Perseverance in solving a problem

Students' attitudes towards mathematics are shaped by their learning experiences. Making the learning of mathematics fun, meaningful and relevant goes a long way to inculcating positive attitudes towards the subject. Care and attention should be given to the design of the learning activities, to build confidence in and develop appreciation for the subject.

## METACOGNITION

**Metacognition**, or "thinking about thinking", refers to the awareness of, and the ability to control one's thinking processes, in particular the selection and use of problem-solving strategies. It includes monitoring of one's own thinking, and self-regulation of learning. The provision of metacognitive experience is necessary to help students develop their problem solving abilities. The following activities may be used to develop the metacognitive awareness of students and to enrich their metacognitive experience:

- Expose students to general problem solving skills, thinking skills and heuristics, and how these skills can be applied to solve problems.
- Encourage students to think aloud the strategies and methods they use to solve particular problems.
- Provide students with problems that require planning (before solving) and evaluation (after solving).
- Encourage students to seek alternative ways of solving the same problem and to check the appropriateness and reasonableness of the answer.
- Allow students to discuss how to solve a particular problem and to explain the different methods that they use for solving the problem.

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