

Teaching and Learning of Science and Mathematics in Schools—Towards a More *“Creative and Innovative Malaysia”*



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Science and Mathematics
in Schools—Towards a More**
“Creative and Innovative Malaysia”



Academy of Sciences Malaysia

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Preface

Education in science and mathematics has come into focus within the business and academic communities. The domestic and world economies depend more and more on science and engineering but our primary and secondary schools seem to have limits in producing enough students with interest, motivation, knowledge and skills they need.

Science and mathematics education in primary and secondary schools is a fundamental stepping stone towards the promotion of capacity building of any country. It enables countries to rapidly transfer and utilize the scientific knowledge being generated within the specific community throughout the country.

The ASM Science Education Committee organised two workshops, the *National Science and Mathematics Education Workshops for Stakeholders 2010*, designed and organized to bring together educators, scientists, education industry experts and stake holders to discuss and, share knowledge and ideas pertaining to important issues in science and mathematics education in the country. The first workshop, held in Shah Alam, had the theme “*Warga Malaysia Berinovatif dan Berkreatif*” Creative and Innovative Malaysians” which grew from the the urgent need to educate the young so that they could enjoy and ultimately appreciate and utilise the power of science and mathematics to help the country achieve its Vision 2020. The second workshop held in Kota Kinabalu, was pertaining to important issues in science and mathematics education for rural schools in Sabah, Sarawak and Labuan. The theme “Meeting the Needs of Rural Schools on Innovative and Creative Teaching in Science and Mathematics/ *Memenuhi Keperluan Sekolah luar Bandar dalam Pembelajaran Berinovatif dan Berkreatif dalam Sains dan Matematik*” was to identify the issues faced by science and mathematics teachers from rural schools in educating the young so that they could enjoy, ultimately appreciate and utilise the power of science and mathematics to help the country achieve its Vision 2020 as well as the aspirations of the New Economic Model, launched by the YAB Prime Minister.

The ideas shared in both these Workshops provide the feedback from a cross-section of educators, scientists, education industry experts as well as other stake holders to further build children’s capacities in using science and mathematics. Ideas generated at the Workshops were incorporated as our input into the ASM Advisory Report on the teaching and learning of science and mathematics to be forwarded to the Ministry of Education, other relevant ministries and agencies for their consideration.

Last, but not least, we would like to extend our sincere appreciation to the Ministry of Education, PETROSAINS, and MARA as well as to all the participants, invited speakers and rapporteurs for their undivided support and assistance in making the development of this Advisory Report a success.

Prof Ir. Dato’ Chuah Hean Teik, FASc.

Chairman

ASM Science Education Committee

Academy of Sciences Malaysia

Foreword

I would like to convey my heartiest congratulations to the Academy of Sciences Malaysia's Science Education Committee for this Advisory Report on the Teaching and Learning of Science and Mathematics in Schools. This effort would not have been possible without the strong support and co-operation that ASM had received from the Ministry of Education, PETROSAINS, and MARA as well as the many educators, scientists, education industry experts and stakeholders who had gathered together in two Workshops organised by ASM.

The Academy strongly believes that the education of science and mathematics in Malaysian primary and secondary schools through qualified and strongly committed teachers will go a long way to enhancing and sustaining Malaysia's economic growth in this globalised world in the near future. A strong foundation and grounding in the sciences and mathematics in our children are necessary prerequisites to further ensure that Malaysia's vision of achieving a high-income nation is achieved by 2020. There are ample examples of developing countries worldwide using science and mathematics to develop new technologies locally and identifying opportunities in science and technology to progress sustainably through knowledge generation, wealth creation and social well-being.

This Advisory Report is yet another important initiative of the Academy of Sciences Malaysia in an effort to making the teaching and learning of science and mathematics 'fun and interesting'. We are hopeful that the Government will consider implementing the two strategies and the action plans proposed in the Report.

Tan Sri Datuk Dr Ahmad Tajuddin Ali, FASc.

President

Academy of Sciences Malaysia

ASM Science Education Committee

Chairman

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RINGKASAN EKSEKUTIF

Bengkel Pendidikan Sains dan Matematik Kebangsaan yang dianjurkan oleh Akademi Sains Malaysia (ASM) pada Februari 2010 telah disertai oleh 165 peserta. Peserta-peserta bengkel ini terdiri daripada guru-guru daripada empat aliran pendidikan yang berlainan (sekolah awam, sekolah swasta, sekolah aliran agama dan Maktab Rendah Sains MARA), pendidik guru dari universiti, ahli akademik bidang sains di universiti, pembuat dasar dari tiga kementerian (MOE, MOHE, MOSTI) dan NGO profesional. Sebahagian besar guru yang terlibat adalah pakar subjek yang cemerlang (Guru Cemerlang) dengan pengalaman luas dalam pengajaran dan pembelajaran (P&P) Sains dan Matematik. Tujuan utama bengkel tersebut adalah untuk mengenalpasti isu dan cabaran yang dihadapi oleh guru dalam melaksanakan kurikulum dan dasar pendidikan yang telah ditetapkan.

Ramai merasakan bahawa kurikulum Sains dan Matematik adalah tidak relevan, sempit, kaku dan berat. Isu latihan guru turut dibincangkan dengan meluas. Terdapat kelemahan dalam latihan guru sedia ada kerana rata-rata guru dilihat tidak profesional, kurang berkualiti dan kurang berdedikasi dalam profesion keguruan. Guru perlu mempunyai pengetahuan meluas dalam subjek masing-masing disamping memiliki pelbagai ilmu pedagogi dan ilmu kemahiran berfikir agar P&P dapat berjalan dengan efektif bagi setiap murid. Sehubungan itu, peranan guru sebagai *role model* untuk menyemai budaya pembelajaran sepanjang hayat dan nilai sosial di kalangan pelajar juga tidak dapat dipikul dengan sebaik-baiknya. Selain itu, faktor pemilihan calon guru juga memainkan peranan penting dalam profesion keguruan. Turut diakui bahawa ramai bertindak memilih menjadi guru sebagai pilihan kerjaya terakhir dan akibatnya profesion keguruan tidak dapat dijiwai dengan sepenuhnya. Tambahan pula, mereka tidak mempunyai kelayakan akademik yang kukuh. Di samping itu, banyak isu bersangkutan ketidaksempurnaan sokongan infrastruktur dan infostuktur telah dibangkitkan dan dibentangkan. Kekurangan dalam kedua-dua perkara ini pastinya akan memberi kesan kepada keberkesanan dan kecekapan dalam P&P, termasuk pengajaran kemahiran manipulasi dan tahap pemikiran yang lebih tinggi.

Situasi ini bertambah buruk di sekolah-sekolah luar bandar yang tidak dilengkapi 'bilik sains', makmal dan ruangan komputer serta peralatan yang berkaitan. Latihan amali dalam kemahiran manipulatif juga langsung tidak diajar kepada murid atau sekadar diberikan demonstrasi ringkas oleh guru. P&P yang merosot ini turut dipengaruhi oleh kekurangan guru opsyen Sains dan Matematik di sekolah-sekolah luar bandar. Ramai diantara mereka ingin keluar daripada keadaan tersebut sejurus melihat infrastruktur dan infostruktur di sekolah mereka melaporkan diri. Oleh itu adalah diakui bahawa guru enggan berkhidmat di sekolah-sekolah luar bandar. Isu tentang kemampuan dan kecekapan guru dalam penggunaan alat bantu mengajar terkini, iaitu ICT dan internet, turut diketengahkan. Ramai berpendapat melatih guru supaya mahir ICT adalah sangat perlu dan penting untuk membolehkan mereka mengajar dengan lebih efektif dan menyeronokkan. Guru juga mengeluh bahawa mereka terlalu dibebani dengan tugas pentadbiran dan mengakibatkan mereka terpaksa mengambil masa yang lama untuk membangunkan bahan bantu mengajar yang efektif dan menarik perhatian murid mahupun untuk memikirkan projek yang mampu mencabar minda murid. Seterusnya, masalah pada kurangnya bahan bacaan berkaitan Sains dan Matematik dalam Bahasa Melayu didapati menghalang capaian kepada sumber kaya dengan ilmu yang kebiasaannya diperoleh dalam Bahasa Inggeris.

Isu-isu disebut di atas dan tekanan kepada guru untuk menghasilkan keputusan peperiksaan cemerlang telah menjadikan sistem pendidikan negara kita berat sebelah dan ketara berorientasikan peperiksaan. Situasi ini tidak memberi banyak insentif kepada guru untuk berinovasi secara praktikal (*hands-on*) serta membangunkan bahan-bahan pengajaran berasaskan aktiviti dalam kelas yang berupaya untuk mengembangkan kemahiran berfikir pelajar kepada tahap yang lebih tinggi. Lantas ia menjadi penyebab utama murid berasa bosan dan tidak bermotivasi untuk mempelajari Sains dan Matematik. Akibatnya penyertaan murid dalam program dan aktiviti berlandaskan Sains

dan Matematik akan semakin berkurangan pada tahun-tahun berikutnya. Ini seterusnya menimbulkan jurang yang besar dalam mencapai sasaran untuk menghasilkan tenaga kerja berpengetahuan (*k-workers*) kompetitif dan sesuai untuk mengisi tempat kerja masa depan bagi memastikan ekonomi negara yang berterusan.

Hampir keseluruhan guru-guru dari KPM yang terlibat di dalam Bengkel pertama di Shah Alam adalah guru (sebahagiannya adalah Guru Cemerlang) dari kawasan bandar yang mana kemudahan sekolah dan ICTnya adalah lebih baik, lengkap dan dan diselenggara. Maklum balas dari Bengkel pertama ini mengutarakan kemungkinan bahawa situasi di Sarawak dan Sabah di mana sebahagian besar sekolah-sekolah di kedua negeri ini berada di kawasan luar bandar boleh menjadi kurang baik dari segi infrastruktur dan info-struktur.

Setakat ini, tiada sebarang laporan atau kajian dilaporkan telah dijalankan bagi mengenalpasti perbezaan prestasi di antara sekolah di kawasan bandar dan sekolah di kawasan luar bandar Sabah/Sarawak dari segi prestasi akademik dan kebolehan kognitif pelajar. Dan sekiranya terdapat sebarang kajian yang telah dijalankan, bagaimanakah terdapat perbezaan disebabkan oleh ketidakcukupan kemudahan dan kekurangan guru-guru sains dan matematik yang berkhidmat di sekolah luar bandar. Adakah masalah yang dialami sekolah di kawasan luar bandar ini turut dialami oleh sekolah di kawasan bandar? Persoalan-persoalan ini seterusnya membawa kepada penganjuran Bengkel kedua bagi mengumpul maklumbalas daripada peserta yang rata-rata dari sekolah luar bandar Sabah dan Sarawak bagi mendapatkan pemahaman yang lebih mendalam mengenai isu-isu ini dan pada masa yang sama bagi mengenalpasti tindakan strategi yang sesuai bagi mengatasi masalah-masalah yang dialami.

Hasil daripada kedua-dua Bengkel menunjukkan isu yang paling utama adalah pelaksanaan dasar pendidikan dan sistem penyampaian di peringkat sekolah yang mengalami cabaran dan masalah. Ini sedikit sebanyak dipercayai akan mengganggu rancangan kerajaan untuk melahirkan masyarakat yang berpendapatan tinggi di bawah Model Ekonomi Baru (NEM), terutamanya di Sabah dan Sarawak. Sumber manusia yang mencukupi dengan taraf pendidikan bagi memasuki pasaran kerja adalah penting bagi memastikan tenaga kerja yang kompetitif dalam kelangsungan hidup di dalam ekonomi global.

Ini merujuk kepada bilangan tinggi tenaga kerja yang terampil dan profesional dengan pendidikan tinggi di negara yang mempunyai ekonomi yang lebih maju. Pendapat mengatakan sejumlah besar tenaga kerja yang terampil/profesional akan menyumbang kepada cukai pendapatan yang lebih tinggi kepada kerajaan dan mempunyai kesihatan serta penglibatan kepada masyarakat yang lebih baik. Hal ini akan memberikan saluran keluar dari kemiskinan dan kemelesetan. Pekerja berpendapatan tinggi kebiasaannya akan dijawab oleh lulusan universiti. Bagi mereka yang meninggalkan sekolah dengan kelayakan yang rendah akan hilang peluang untuk melanjutkan pelajaran ke peringkat yang lebih tinggi dan seterusnya kurang berpeluang untuk menjawab jawatan kerja yang berpendapatan tinggi. Jelas di sini, bahawa kualiti pendidikan sekolah merupakan teras dan asas di dalam membentuk tenaga kerja yang terampil berasaskan ilmu sains, kejuruteraan dan teknologi. Masyarakat yang berpendapatan tinggi sangat bergantung kepada sistem pendidikan yang berkesan untuk semua sekolah; samada di luar bandar atau bandar.

Kesan langsung daripada keengganan guru-guru untuk berkhidmat di sekolah-sekolah luar bandar di Sabah dan Sarawak; banyak mempengaruhi pengajaran dan pembelajaran sains dan matematik. Selain itu, antara perkara lain yang diutarakan oleh peserta bengkel adalah kepelbagaian kumpulan etnik di Sabah dan Sarawak yang berlainan budaya dan bahasa. Terdapat sebanyak 32 bahasa etnik yang berbeza digunakan oleh penduduk tempatan, untuk menguasai sekurang-kurangnya salah satu bahasa untuk perbualan yang berkesan dengan penduduk tempatan selalunya TIDAK mudah, apatahlagi tujuan berkomunikasi untuk mengajar dan memberi pengetahuan kepada kanak-kanak. Guru yang baru memulakan perkhidmatan di sekolah untuk pertama kali sering menghadapi masalah komunikasi dengan pelajar. Situasi yang sama turut dialami guru-guru di Sarawak, di mana secara rasmi terdapat 40

kumpulan sub-etnik yang berbeza. Masing-masing mempunyai budaya, bahasa dan gaya hidup tersendiri. Namun, beberapa kumpulan etnik di Sarawak lebih besar berbanding dengan Sabah yang mana kumpulan-kumpulan etniknya kebiasaannya lebih kecil. Telah diusulkan saranan untuk sekolah atau JPN menyediakan beberapa kursus bahasa pengantar tempatan untuk para guru yang baru ditempatkan di sekolah. Ini bertujuan untuk membantu mereka menyesuaikan diri dengan lebih cepat dan baik dalam persekitaran yang baru.

Telah difahamkan bahawa langkah-langkah dan tindakan telah diambil untuk meningkatkan kadar kekurangan urusan sekolah di Sabah dan Sarawak dan untuk meningkatkan kualiti pengajaran dan pembelajaran pelajar. Tindakan kecil ini perlu diambil untuk meningkatkan taraf hidup dan taraf pendidikan di negeri Sabah dan Sarawak supaya mempunyai tahap yang sama dengan sekolah-sekolah di kawasan bandar Sabah, Sarawak dan Semenanjung Malaysia. Namun, dilihat dari masalah-masalah mendesak yang melibatkan penyediaan infrastruktur yang sangat asas seperti air bersih dan elektrik, sistem pengangkutan jalan dan air diperlukan untuk perhubungan mudah ke kawasan-kawasan pedalaman dan terpencil, diikuti dengan perhubungan melalui media elektronik dan telekomunikasi; dan kesihatan yang diperlukan untuk kesejahteraan para pelajar, guru dan masyarakat. Jelas bahawa masa, wang dan komitmen dari pihak berkuasa berkaitan adalah diperlukan untuk langkah ini.

Memandangkan terdapat isu-isu utama yang melangkaui pelbagai kementerian, maka adalah baiknya isu-isu ini ditangani di peringkat kebangsaan. Beberapa isu yang memerlukan perhatian dan penambahbaikan pada dasarnya telah diletakkan di bawah Bidang Keberhasilan Utama Negara (NKRA) yang telah dirasmikan YAB Perdana Menteri pada September 2010 di bawah ‘Meningkatkan Mutu Penuntut’. Mereka terpaksa berhadapan dengan masalah kemudahan paling asas seperti bekalan air bersih dan elektrik, perumahan yang usang dan terpaksa merentasi hutan untuk pergi dan keluar dari sekolah yang terpencil, dan yang terkesan sekali mereka terputus komunikasi dengan dunia luar untuk jangka waktu yang lama apabila ditempatkan di sekolah pedalaman.

Isu ini berada di bawah salah satu daripada enam NKRA iaitu “Meningkatkan prasarana luar bandar” yang mendapat perhatian kerajaan. Adalah diharapkan bahawa langkah-langkah komprehensif yang diambil berdasarkan NKRA dapat diterjemahkan terus ke dalam penambahbaikan kemudahan sekolah, keadaan hidup para guru, serta kemudahan lain seperti pengangkutan dan telekomunikasi.

Dibantu oleh NKRA yang lain, iaitu ‘Meningkatkan taraf hidup isi rumah berpendapatan rendah’, ia seharusnya berupaya untuk membasmi kemiskinan tegar dan menaikkan status sosial-ekonomi dan kesihatan umum masyarakat luar bandar secara menyeluruh. Perubahan keadaan hidup masyarakat luar bandar di kedua-dua negeri ini kepada keadaan yang lebih baik dipercayai sedikit sebanyak dapat membawa peningkatan bilangan guru berkhidmat di kawasan ini.

Oleh itu, cabaran dan permasalahan dihadapi oleh para guru dan JPN dalam menguruskan sekolah luar bandar sangat berbeza berbanding dengan sekolah-sekolah di bandar, yang sekurang-kurangnya mendapat bantuan sumber terus dari Kementerian. Kualiti guru kekal menjadi satu isu yang menekan. Oleh demikian, perubahan semula (*revamp*) proses pemilihan guru baru dan latihan kepada guru sedang berkhidmat perlu untuk meningkatkan kecekapan mereka dalam pengisian pembelajaran dan mempersiapkan mereka untuk mengambil pedagogi baru seperti penyelidikan berasaskan mengajar dan metodologi pembelajaran.

Strategi ini memerlukan penstrukturan semula program pendidikan di universiti dan institut perguruan. Pemilihan guru terbaik merupakan satu strategi digunapakai oleh negara-negara maju dalam membangunkan sumber tenaga kerja berpengetahuan untuk terus menerajui kedudukan mereka dalam bidang sains, kejuruteraan dan teknologi dan tentunya k-ekonomi.

Hal ini tentu memerlukan penyusunan semula dari program pendidikan di fakulti pendidikan dari universiti dan kolej pendidikan. Memilih yang terbaik untuk menjadi guru adalah strategi yang diterimapakai oleh negara-negara maju untuk membangunkan sumber berterusan K-tenaga kerja untuk mempertahankan kedudukan terdapan mereka pada ilmu pengetahuan, teknik dan teknologi dan tentu saja K-ekonomi mereka.

Berdasarkan maklum balas daripada kedua-dua Bengkel yang telah dijalankan [lihat Jilid 2 dan 3], ASM ingin mengutarakan dua (2) Strategi kepada pihak berkepentingan tertentu dalam mengatasi isu-isu yang telah dikenalpasti. Kedua-dua strategi ini adalah dianggap sebagai strategi utama. Pada dasarnya, isu-isu ini dikenalpasti berpunca dari kurangnya pelaksanaan dasar yang berkesan di peringkat sekolah serta ketiadaan badan pada peringkat nasional untuk memantau penyelarasan dan hubungan antara kementerian yang bersangkutan dengan pelaksanaan dasar di semua peringkat. Oleh itu, ASM mencadangkan strategi seperti berikut yang menyasarkan pihak berkepentingan dan memastikan pelaksanaan dasar oleh Kerajaan berkesan dalam meningkatkan mutu Sains dan Matematik di semua sekolah bandar mahupun luar bandar:

Strategi 1. Menubuhkan Majlis Pendidikan Negara — KPM

Majlis Pendidikan Negara dibentuk berdasarkan Majlis Sumber Air Negara, Majlis Tanah Negara, Majlis Perhutanan Negara dan Majlis Perancangan Negara, yang mana kesemuanya mengabungkan pihak berkepentingan dari negeri dan pusat bagi membuahkan persetujuan dalam isu infra-struktur dan info-struktur yang memberi kesan kepada pendidikan, termasuklah di dalam perancangan spasial.

Peranan Majlis ini adalah untuk membentuk dasar pendidikan yang relevan, merancang strategi dan memulakan tinjauan biasa sebagai pihak berkepentingan yang utama dan peneraju bagi semua projek berkaitan infrastruktur and infostuktur pendidikan seluruh negara.

Majlis ini akan dipengerusi oleh YAB Perdana Menteri dengan ahli-ahli terdiri dari Menteri Besar/Ketua Menteri kesemua negeri serta Kementerian yang berkaitan seperti Kementerian Pendidikan, Kementerian Kerja Raya, Kementerian Teknologi Hijau, Tenaga dan Air, Kementerian Sains, Teknologi dan Inovasi, Kementerian Kewangan, Kementerian Pendidikan Tinggi, Unit Perancangan Ekonomi, pelbagai pihak berkepentingan yang terlibat di dalam pendidikan dan penjawatan seperti Kementerian Sumber Manusia, Persekutuan Pekilang-Pekilang Malaysia (FMM), Persatuan Kolej dan Universiti Swasta Malaysia (MAPCU), Majlis Naib Canselor, Majlis Profesor Negara (NPC), Kesatuan Perkhidmatan Perguruan Kebangsaan Malaysia, UNIK, Persatuan Ibubapa dan Guru Negara, Akademi Sains Malaysia, dan dengan Kementerian Pendidikan sebagai secretariat.

Strategi 2. Menubuhkan Jawatankuasa Pengurusan Pendidikan di Peringkat Negeri — KPM

Jawatankuasa ini akan ditubuh di peringkat politik Kerajaan Negeri, membenarkan penyelarasan antara pelbagai agensi yang terlibat di dalam pembangunan (dengan infrastuktur yang diperlukan) dan pengurusan sekolah. Model penubuhan Jawatankuasa ini adalah daripada Jawatankuasa Pertanian Negeri atau Jawatankuasa Perindustrian Negeri yang diketuai oleh Menteri Besar/ Ketua Menteri dan Majlis Tindakan Negeri. Ahli jawankuasa ini boleh dipilih daripada agensi berkaitan seperti di peringkat Pusat.

Peranan jawatankuasa-jawatankuasa ini adalah dalam melaksana, memantau dan menilai keberkesanan dan kecekapan pelaksanaan dasar, strategi dan tindakan di peringkat negeri yang dibentuk oleh Majlis Pendidikan Negara.

Dalam pelaksanaan strategi-strategi di atas, ASM mencadangkan lapan rancangan pelaksanaan. Kesemua

rancangan pelaksanaan ini dianggap penting. Walaubagaimanapun, sekiranya keutamaan perlu ada, berikut merupakan senarai keutamaan yang perlu diambil kira:

Rancangan Pelaksanaan 1. Meningkatkan Latihan Guru-guru Profesional — KPT/KPM.

Rancangan Pelaksanaan ini akan pasti hanya yang layak terpilih untuk dilatih menjadi guru. Hanya mereka yang benar-benar ingin menjadi guru dan komited sahaja yang akan dipilih bagi memasuki latihan. Program pembelajaran dan latihan yang diperbaiki dan lebih meluas dengan adanya peningkatan dalam penggunaan ICT akan melahirkan lebih ramai guru-guru yang berkecukupan dan bagus di masa hadapan.

Rancangan Pelaksanaan 2. Memperbaiki Skim Perkhidmatan Guru — KPM (Bahagian Pengurusan Sumber Manusia)/ JPA.

Rancangan Pelaksanaan ini akan dapat membantu menarik dan menggalak lebih ramai golongan cemerlang untuk terus kekal dalam perkhidmatan bagi memperbaiki prestasi sekolah awam dan mencapai matlamat KPM iaitu bagi menjadikan sekolah awam sebagai pilihan utama ibu bapa dan pelajar.

Rancangan Pelaksanaan 3. Memperkemas dan Membangunkan Kurikulum Sains Yang Sesuai dengan Keperluan Masa Depan — KPM (Bahagian Pembangunan Kurikulum).

Rancangan Pelaksanaan ini bermatlamat untuk memperkemas kurikulum kini yang dipercayai sempit, kaku dan berat, bagi pelaksanaan dan penyampaian yang lebih baik di peringkat sekolah serta menambak pembelajaran dan pengajaran agar “menarik dan menyeronokkan”.

Rancangan Pelaksanaan 4. Mempertingkatkan Metodologi Penilaian bagi Subjek Sains dan Matematik — KPM (Lembaga Peperiksaan, Majlis Peperiksaan Malaysia).

Rancangan Pelaksanaan ini akan menjadi langkah pertama dalam memperbaiki penilaian kemahiran berfikir dan dalam memastikan kemahiran amali sains dan uji-kaji makmal diuji.

Rancangan Pelaksanaan 5. Mempertingkatkan Kualiti Latihan Pendidikan dan Sistem Penyampaian bagi Menjadikan Pembelajaran Sains dan Matematik Menyeronokkan dan Menarik — KPM (Bahagian Pendidikan Guru).

Bagi menambah kemahiran yang berkaitan untuk mempertingkatkan kebolehan guru-guru untuk memperkenalkan cara pengajaran, termasuk metodologi pembelajaran berasaskan aktiviti. Ini tentunya akan membuatkan pembelajaran sains dan matematik menyeronokkan dan menarik, seterusnya dapat mempertingkatkan penglibatan pelajar dalam karier berasaskan Sains, Teknologi, Kejuruteraan dan Matematik dalam kehidupan mereka.

Rancangan Pelaksanaan 6. Melaksanakan Kembali Dasar Pengajaran Sains dan Matematik Menggunakan Bahasa Inggeris Sebagai Bahasa Pengajaran di Peringkat Sekolah Menengah ke-atas — KPM (Bahagian Pembangunan Kurikulum).

Rancangan pelaksanaan ini adalah bagi mengembalikan semula dasar pengajaran Sains dan Matematik menggunakan Bahasa Inggeris sebagai bahasa pengajaran di peringkat Sekolah Menengah (tingkatan 1 ke atas) sehingga ke peringkat universiti.

Rancangan Pelaksanaan 7. Mempertingkatkan Sokongan Infrastruktur dan Infostruktur — KPM (Bahagian Perolehan dan Pengurusan Aset, Bahagian Teknologi Pendidikan)

Rancangan Pelaksanaan ini adalah bagi memastikan rancangan KPM dalam melengkapkan dan meningkatkan kemudahan sains dan ICT di semua sekolah, bagi kawasan bandar dan luar bandar, terlaksana dengan jayanya.

Rancangan Pelaksanaan 8. Mempertingkatkan Pengurusan Pendidikan dan Sekolah — KPM (Bahagian Pengurusan Sekolah Harian).

Memberi sokongan yang diperlukan di sekolah dari kementerian kepada guru-guru bagi membantu guru-guru meningkatkan kecekapan dan keberkesanan penyampaian mereka dan bagi mencapai target Pelan Induk dan dasar pendidikan.

Diharapkan dengan pelaksanaan dua strategi utama dan lapan rancangan pelaksanaan yang dicadangkan ini, aspirasi Model Ekonomi Baru (NEM) yang telah diperkenalkan oleh YAB Perdana Menteri untuk mendapatkan ekonomi yang bertaraf tinggi lagi menyeluruh, akan dicapai.

EXECUTIVE SUMMARY

At the National Science and Mathematics Education Workshop organized by the Academy of Sciences Malaysia (ASM) in February 2010 and participated in by 165 teachers from four different education streams (public school, private school, religious school and MARA), teacher educators from the universities, academics from the sciences in the universities, policymakers from three ministries (MOE, MOHE, MOSTI) and professional NGOs deliberated on the teaching and learning of science and mathematics in schools; many issues and challenges of implementing the curriculum and education policies at the school level were identified by the teachers themselves. Most of the teachers selected by MOE are excellent subject specialists ('Guru Cemerlang') with many years of experience in teaching science and mathematics.

Many felt that the curriculum for science and mathematics was not relevant and was cramped, rigid and heavy. Where teachers were concerned, short-comings related to dedication and ability to impart the curriculum content, knowledge, learning and thinking skills for life-long learning and social values to the pupils were discussed. It was recognized that those selected to become teachers were usually NOT the best candidates and many were 'reluctant' teachers with teaching as their last career choice. Many issues on lack of infra-structure and info structure support were raised, brought forth and linked to their impact on the efficiency and effectiveness in the delivery of lessons, teaching manipulation and imparting of higher order thinking skills. This situation was made worse in the rural schools which very often were without 'science rooms', laboratories, computer rooms and the accompanying equipment. Practical training on manipulative skills was not taught at all or were downgraded to just short demonstrations by the teachers. This was further compounded by a serious lack of science and mathematics option teachers in the rural schools, particularly in Sarawak and Sabah. Many teachers were reluctant to be posted to these rural schools and wanted to leave on that the day that they arrived. The low competency and ability of the teachers in employing the latest teaching tools via ICT and the internet were highlighted. Many felt that training teachers to be ICT savvy was essential and important for to make teaching more effective and fun. Teachers also lamented that they were over-burdened with administrative chores and this had eroded on their time for preparation of lessons and, working on teaching aids and projects for students. It was further high-lighted that there was a serious lack of reading materials on science and mathematics in Bahasa Malaysia and this had hampered access to the rich sources of knowledge, normally easily available in English.

Plagued by the various issues mentioned above and the pressure of producing good examination results, the whole education system had become biased and overtly examination-oriented. That did not provide much incentive for teachers to innovate by hands-on, activities-based teaching in the classroom to develop the higher order thinking skills of the students. That had largely contributed to the students finding the learning of science and mathematics boring and not interesting, leading to low participation in science and technology in later years. That left us with another big gap towards achieving the target of creating a competent knowledge workforce suitable for the future workplace to sustain our economy.

Most of the teachers who took part in the first Workshop were teachers (some *Guru Cemerlang*) from the urban areas where schools and ICT facilities are decidedly more complete, better equipped and well maintained. The feedback from the first Workshop raised the real possibility that the situation in Sarawak and Sabah, where most of the schools were in the rural areas, could be even worse. It was not clear whether there had been any report or study on the differential performance between Sabah/Sarawak rural and urban schools in terms of academic performance and cognitive skills ability. If that was so, how much of the differential was due to the inadequacy of facilities and availability of trained science and mathematics teachers in these rural schools. Were the issues facing those schools the same as those plaguing the urban schools? It was with that in mind that the Second Science and Education Workshop was organized with a view of gathering feedback from the participants representing

rural schools in Sabah and Sarawak for a better understanding of those issues and possibly identifying strategic measures to solve their woes.

Findings from both the Workshops demonstrated that the crux of the issue was the implementation of the education policies and delivery system at the school level which had met with problems and challenges. That could derail the plan by the government to create a high-income society under the New Economy Model (NEM), particularly in Sabah and Sarawak. An adequate supply of human resource with appropriate education levels entering the job market is essential towards ensuring a competitive workforce for survival in a global economy. This refers to a high proportion of skilled and professional workers with minimal tertiary education in the advanced economies. This obviously has to draw on the cohort of quality eligible secondary school leavers that also feed the universities and professional colleges. It was opined that a larger employed skilled/professional workforce contribute higher tax revenue for the government, have better health and increases in participation in society. This in turn, provides a conduit out of poverty and recession. As higher-paid jobs are taken up by the growing number of graduates, those leaving schools with poorer qualifications and missing out in gaining a place in institutions of higher learning are facing a very bleak future indeed. It is clear that quality school education is the foundation upon which a skilled workforce based on science, engineering and technology is built. A high-income society depends, first and foremost, on an education system that works effectively for all schools, rural and urban alike.

A direct consequence arising from the reluctance of teachers to serve in the rural schools in Sabah and Sarawak was that good teachers, in particular trained science and mathematics teachers, were difficult to get and many of the schools were lacking in science and mathematics option teachers, hence the quality of teaching and the learning of science and mathematics was greatly affected.

One additional factor that the teachers brought forth was the diversity of the ethnic groups in Sabah and Sarawak that they had to cope with. With as many as 32 different spoken languages used by the different locals, mastering at least one for a working conversation with the locals was often NOT easy, let alone using one to communicate for the purpose of teaching and imparting knowledge to young children. New teachers who arrived at the schools for the first time often faced communication problems with the students. A similar situation was encountered in Sarawak where there were officially 40 sub-ethnic groups each with its own distinct language, culture and lifestyle. However, some of the ethnic groups in Sarawak are large in contrast to those in Sabah where the diverse ethnic groups were usually small. It had been strongly suggested that the schools or JPN provide some introductory courses on local language and culture to the new teachers posted to these schools to assist them to adapt faster and better to the new environment.

It was acknowledged that steps and measures had been taken to alleviate the extreme poor state of affairs of the schools in Sabah and Sarawak and also to improve the quality of teaching and learning of the students. This was just a drop in the ocean of the actions that needed to be taken to bring the standard of living and hence the quality of education of the States of Sabah and Sarawak to be anywhere near those of the urban schools in Peninsular Malaysia. However, judging from many pressing issues involving even the provision of the very basic infra-structure of clean water and electricity supplies, the necessary road and water transport support systems for easy access to these interior and isolated areas, followed by setting up of connectivity through electronic media and telecommunications and the necessary healthcare for the well-being of the students, teachers and the community alike, it was clear that it would take time, money and commitment of the relevant authorities to resolve these issues.

These were major issues of a mammoth magnitude transcending many ministries and hence were better tackled at the national level. Some of the issues that needed attention and improvement had in fact been embedded

in the New Key Results Areas (NKRA) unveiled by the Prime Minister himself in September 2010 in the ambitious Malaysian Government Transformation Programme under the Heading ‘Improving Student Outcomes’. The teachers had to cope with the very basic amenity issues of clean water and electrical supplies, dilapidated housing and the dreadful prospects of having to track through the jungles by primitive means to get to and from the isolated schools, and even worse had to endure a complete cut off of communication with the outside world for extended periods after being posted to schools in the interior.

These came under one of the six major NKRA areas under “Improving rural basic infra-structure’ that was receiving close attention from the government. It was hoped that the comprehensive measures taken under NKRA could be translated immediately into improvement in school amenities and facilities, living conditions for teachers and accessibility as in terms of transportation and telecommunication. Aided by another NKRA on ‘Raising the living standards of low-income households’, these should help to eradicate the hard-core poor and elevate the overall social-economical standing and general healthiness of the rural community. A change for the better in the living conditions of the rural community in the two states might bring about increased willingness of teachers to serve in these areas.

Thus the challenges and issues faced by the teachers and JPN in managing rural schools were very different compared to those of the urban schools, though they were at least surmountable with resources from within the Ministry. The quality of teachers remained a pressing one and it called for a complete revamp of the selection process for new teachers and, a re-training and upgrading of existing teachers who were already in the service, to enhance their content competency and preparing them to take on new pedagogy such as enquiry-based teaching and learning methodology. This necessarily entailed a re-structuring of the education programmes in the education faculties of the universities and the education colleges. Selecting the best to be teachers was a strategy adopted by the advanced nations to develop a sustainable source of K-workforce to maintain their leading positions on science, engineering and technology and of course, in their K-economy.

Based on the feedback from the two Workshops [see Volumes 2 and 3], ASM has drawn up two strategic measures targeting specific stakeholders to address the pertinent issues. Both these strategies would be considered as major strategies. The crux of the issues appears to be the lack of an effective implementation of the policy at the school level and the lack of a national body to oversee the coordination across ministries on all issues affecting the implementation of the policy at every level. ASM has drawn up two strategic measures targeting specific stakeholders to address and ensure the successful implementation for the policies put forward by the Government in raising the standards of science and mathematics in all schools, both urban and rural, as follows:

Strategy 1. *Establish a National Education Council (NEC) — MOE*

The National Education Council (NEC) would be modeled by the National Water Resources Council, National Land Council, the National Forestry Council and National Spatial Planning Council, all of which bring State and Federal stakeholders together, to engender a consensus on infra-structure and info-structure issues affecting education, including spatial planning, respectively.

The role of the Council would be to formulate relevant education policies, plan strategies and initiate regular reviews as the main stakeholder and driver for all education infrastructure and infostructure-related projects throughout the nation.

The Council would be chaired by the Prime Minister with members such as the Menteri Besar/ Chief Ministers of all the states and others drawn from the relevant Ministries such as the Ministry of Education; Ministry of Works;

Ministry of Green Technology, Energy and Water; Ministry of Science, Technology and Innovation; Ministry of Finance; Ministry of Higher Education and the Economic Planning Unit, various stakeholders connected with education and employment such as the Ministry of Human Resources, Federation of Malaysian Manufacturers (FMM), Malaysian Association of Private Colleges and Universities (MAPCU), Council of Vice Chancellors, National Professors Council (NPC), National Union of the Teaching Profession Malaysia, UNIK, National Parents-Teachers Association, Academy of Sciences Malaysia, and with the Ministry of Education as the Secretariat.

Strategy 2. *Establish State Education Committees (SEC) — MOE & JPN*

These committees would be at the political level of Government, allowing coordination among the various agencies involved in the siting, construction (with necessary infrastructure in place) and management of schools. The model for this would be State Agriculture Committees or State Industrial Committees that are headed by Menteri Besar/ Chief Minister, State Executive Councillors or State Ministers. Members of these Committees would be drawn from the corresponding agencies as at the Federal level.

The roles of the Committees would be in implementing, monitoring and evaluating the efficiency and effectiveness of the policies, strategies and actions developed by the NEC at the state levels.

ASM is proposing eight action plans towards implementing these strategic measures. All of these action plans are considered important. However, if some prioritization needs to be incorporated, then the following prioritized list should be used:

Action Plan 1. *Enhance the Training of Professional Teachers — MOHE/MOE.*

This action plan would ensure that only the cream of the eligible candidates would be selected to be trained to become teachers. Only those who wanted to take up teaching as a profession and were committed would be chosen to enroll for training. The revamped and more encompassing teacher educating programme with its enhanced ICT component would produce better and more competent teachers for the future.

Action Plan 2. *Improve Teachers' Service Schemes — MOE (Human Resource Management Division) /JPA.*

This action plan would assist in attracting and retaining the best brains to remain in the service to enhance the performance of public schools and achieve the aim of MOE that the public schools remain the ultimate choice of parents and students.

Action Plan 3. *Review and Develop the Science Curriculum to Meet Future Needs — MOE (Curriculum Development Division).*

This action plan would aim to revise the current curriculum which was cramped, rigid and heavy for better implementation and delivery at the school level and to make the teaching and learning of science and mathematics “fun and interesting”.

Action Plan 4. *Improve the Assessment Methodology for Science and Mathematics Subjects — MOE (Examination Syndicate, Examination Council).*

This action plan would initiate a revamp to enhance the assessment of higher order thinking skills and to ensure that laboratory experimental practical skills are tested.

Action Plan 5. *Improve the Quality of Education Training and the Delivery System to Make Learning of science and Mathematics More Fun and Interesting — MOE (Teacher Education Division).*

This action plan would aim to impart the necessary skills to raise the ability of teachers to improvise and innovate in new teaching methods, including activity-based learning methodology. These would make the learning of science and mathematics more fun and interesting, and increase the participation of students in STEM-based careers in their life.

Action Plan 6. *Reinstate the Policy of Teaching of Science and Mathematics in English from Secondary Schools Onwards — MOE (Curriculum Development Division).*

This action plan would aim to re-establish the policy of teaching science and mathematics by using English as the medium of teaching for students of Form 1 onwards through into the University stage.

Action Plan 7. *Improve the infra-structure and info-structure Support — MOE (Procurement and Asset Management Division, Educational Technology Division)*

This action plan would ensure that the plan of MOE of equipping and improving the science and ICT facilities in all schools, both rural and urban, would be successfully implemented.

Action Plan 8. *Improve Education and School Management — MOE (School Management Division)*

This action plan would provide the necessary support in schools and the Ministry for teachers to improve the efficiency and effectiveness of their delivery and thus allow the set target of the Master Plan and education policy to be achieved.

It is hoped that with the implementation of the two major strategic measures and the eight action plans, the aspirations of the New Economy Model unveiled by the Hon. Prime Minister for a high-value economy and inclusiveness, would be achieved.

PREAMBLE

The economy wellbeing of a nation depends very much on the competitiveness of its industries in the global market which in turn relies on the education system of the nation to produce a competent workforce capable of sustaining the economy. In the present economic environment of intense competition in global business, innovation through science and technology is the key to success and sustainability. Digital- and tech-savvy knowledge workers are one of the drivers of the economy. Many of the developed nations have been able to train, if not to attract, these K-workers for their industries. They have become well ahead of the rest of the world in harnessing innovation and technology to create wealth. It is crystal clear that education, in particular education in science and technology does play a pivotal role in providing the much needed human capital for this development.

If one were to examine the success of these economies, it is not difficult to see that these nations have a very well developed education system and programme in place, in particular on the teaching and learning of science and mathematics in their schools. Students are introduced to these subjects from a young age and hence they have a head start in developing interest and awareness of these topics. They also have a long history and tradition of learning natural sciences and mathematics in their societies. In the current context, their teaching style is more focused on student-centred type of learning, made interesting and fun through innovative teaching techniques. There is now an emerging trend to move on towards an activity-based learning model in the teaching and learning of science and mathematics.

The learning landscape was drastically changed with the advent of the internet and the ubiquitous presence of personal computers. ICT has helped to create independent learning pathways for the students and allow them to develop new skills and talents. Many changes on the teaching and learning of science and mathematics have since been made to keep abreast with the technological advances.

These have involved changes to the education policy, implementation plan, curriculum content and cognitive domain development, methodology and assessment of teaching and learning efficiency, in particular in science and mathematics. This has already taken place in many countries, in particularly in advanced economies such as USA, UK, Finland and France where they had viewed with urgency the need to change and improve their science and mathematics education to boost innovation and hence spur the slowing economies after a series of surveys and feedback from the various quarters indicated a decline in quality and number of manpower with science, technology, engineering and mathematics (STEM) skills.

GLOBAL SCENARIO: SELECTED REVIEW

A UK Study

For example, in a ‘State of the Nation Report’ published in 2008 by the Royal Society United Kingdom [1] on the key trend of participation and attainment of 14–19 year olds in Science and Mathematics Education from 1996 to 2007, it was found that the number of students taking chemistry, physics and mathematics had fallen over this period. Education in UK was failing to provide the increase in the numbers of school-leavers with science and mathematics qualifications as required by industry, business and the research community to assure the UK’s future economic competitiveness. The findings were worrying, considering the needs of industry and business for STEM skills, the UK government’s desire to increase the number of STEM graduates and the need for more science and mathematics teachers. The finding also showed that attitudes to science and mathematics were less positive at the end of the secondary schooling. This was underpinned by the perception that careers in science generally

lacked appeal and the higher relative difficulty of science and mathematics subjects. It was recommended that strengthening the collection of data and using it to facilitate consistent and coherent evaluation of performance and participation in public examinations, a robust system for continuous monitoring of standards and an independent body responsible for curriculum reform should be put in place, amongst others.

The USA Strategy

Another OECD country United States of America, had in 2005 realized the erosion of their leadership in science and technology and had requested the USA National academies' committee on science, engineering and public policy (COSEPUP) to urgently identify '10 actions that the federal policymakers could take to enhance their science and technology enterprise so the USA could successfully compete, prosper and be secure in the global community of the 21st century? What strategy could be used to implement each of those actions?'

The study by COSEPUP culminated in a voluminous report called 'Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future' published in 2007 [2]. Recommendations were embodied in four actions namely in improving K-12 (equivalent to secondary school levels) science and mathematics education (10,000 teachers, 10 million minds); research (sowing the seed), higher education (best and brightest) and economic policy (incentives for innovation). Some actions involved changes in the law. Others required financial support, reallocation of existing funds or new ones. It was also noted that the nation (USA) was unlikely to receive some sudden 'wake-up' call; rather the problem was one that was likely to evidence itself gradually over a surprisingly short period.

Only the top **TWO** priorities/ recommendations of the COSEPUP study which are of direct relevance to this position paper are outlined here.

The **highest priority** was to improve the K-12 science and mathematics education through:

- Annual recruitment of 10,000 science and mathematics teachers by awarding competitive 4-year scholarships to the **brightest** students thereby educating 10 millions minds.
- Strengthening the skills of 250,000 teachers through training and education programmes, including Master's programmes.
- Fostering high-quality teaching with world-class curricula, standards and assessment of students learning.
- Enlarging the pipeline of students who are prepared to enter university with a degree in science, engineering or mathematics by increasing the number of students who pass the (equivalent) school public examinations. (Use specialty secondary schools to foster high-quality science, technology and mathematics education; inquiry-based learning to impart valuable laboratory experience).

The second priority was 'Sow the seeds through science and engineering education' through sustaining and strengthening the nation's traditional commitment to long-term basic research that had the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security and enhance the quality of life.

The French Model

In 1996, the French Nobel Laureate Georges Charpak and the French Academy of Sciences founded the *La Main à la pâte* programme for teaching science in primary schools. *La Main à la pâte* means collaborative and hands-on work. The Ministry for National Education of France in 2001 announced the plan to renew the teaching of science and technology in schools based on this programme. In February 2002, new teaching programmes for primary schools were published entitled ‘Discovery of the World’ and ‘Science and Technology’ [3].

It was specifically mentioned that *“it does not require a specialist to conduct scientific activities in the primary school. The experimental investigation work may be simple and the knowledge to be imparted is accessible. The teacher is able to stimulate and share the pleasure and the curiosity of the pupils and to encourage a reasoned exploration of the world around them which they can put into words, into pictures and into arguments. The universe of science in which scientists seek discoveries and engineers create new objects and products is truly within the reach of versatile school teachers and their pupils”*.

The objective was to renew and expand science teaching in primary education and contribute to achieving this aim in other countries too. It **recommended** that teachers implement an inquiry process combining exploration of the world, scientific learning, experimentation, mastery of language and argumentation, so that children deepen their understanding of the objects and phenomena around them. A very well **support system** had been designed for teachers to implement inquiry-based science education.

The programme came with dissemination, empowerment and acknowledgement through recommendations to stakeholders, training and publications, conferences. An extensive networking of teachers, trainers, scientists through field exchanges and internet services was established with a large number of online services, and resources for teachers and trainers through website/portals were provided. It had the involvement of the scientific community (classroom support for teachers). It also provided development and the sharing of teaching resources, in addition to cross-disciplinary and collaborative projects linking dozens of schools. This concept was introduced to many partners, amongst them being China, Colombia, Chile, Brazil, Germany, Egypt where they were evolved and modified to suit the local conditions and successfully implemented.

ASM initiated collaboration in 2002 with the French Academy of Science and its Ministry of Education on this project in conjunction with the Regional Centre for Science and Mathematics Education (RESCAM) which is part of the Southeast Asia Ministers of Education organization (SEAMEO) based in Penang, Malaysia. The initiative received good support then from the Curriculum Development Centre (CDC) and MOE. Three training workshops were organized with participation by the SEAMEO countries. The last one was held in Malaysia in 2006 and it was partly financed by ASM and other regional partners and the Directorate of European and International Relations and Cooperation of the French Ministry of Education (DREIC). However, no further development on this project was reported after that.

The Finnish Success

There is general consensus that Finland had been successful in developing a high performance education system over the past four decades, through significant policy and structural reforms since 1960s. This was reflected in the highly successful performances of Finnish students on a series of international comparative assessments [4], placing them as the best or amongst the best in the world. The distribution of performance on assessments under PISA suggested high and consistent performance standards across schools in the entire education system which was considered generally cost effective and at a level close to the European average.

The success factors given for the effectiveness of the Finnish Education system were:

- Policy development that emphasized on long-term vision and realistic target setting
- Priority given to the building of high educational quality in primary schools that was accessible to all
- The education system was flexible, decentralized and its administration was based on intense delegation and provision of support. The main part of the planning for schools was done by teachers themselves. There was no centralized system for approval of textbooks. Syllabus for upper secondary education was designed to last for 3 years but students might complete it in 2 to 4 years.
- Early intervention, educational counseling and guidance were wide spread in primary and secondary schools. The comprehensive system was geared to accommodate the heterogeneity that occurred within the student groups. Students were given help to be successful in transition from primary to secondary education and second chance paths were created to increase the rate of success. The rather small average size of the classes in Finnish schools did help.
- Special education was closely integrated into normal teaching and was highly inclusive by nature.
- Teachers were highly valued experts with a relatively high degree of autonomy and were well trained at all levels of education and strongly committed to their work. It was noted that teachers taught in order to help their students to learn, not to pass tests. PISA 2003 study provided some evidence for this [4]. Teaching was regarded as a high-status profession in Finland and attracted some of the best secondary school graduates. Only 10% of some 5000 applicants were accepted each year to the Faculties of Education in Finnish universities. All teachers in Finland needed a Master's degree to qualify for a permanent teaching job.

The Taiwanese Experience

Apart from the OECD countries mentioned above, whose leadership in science and technology in the global market was undoubtedly supported by the strong science and mathematics education of their schools system and an excellent R&D culture, the emergence of the Taiwanese economic prowess in recent years was also known to be linked to the strong science and mathematics tradition of her education system.

Taiwan had a long history of investing in science education, dating back to 1950. The government had recognized the importance of science education in strengthening national power and in acquiring modern technology. Basically, they have gone through two major periods of Science Education Reform called the *Imported Science Education* period from 1949 to 1973 and the *Self-running Science Education* period from 1974 to 2005 [5]. The first period was characterized by classical science education based on mixed Chinese and Japanese models from 1949 to 1957. This was followed by the Sputnik (academic oriented) science education system comprising the Junior High Naffied Science model of UK and the Senior High Science model of USA spanning 1958 to 1974. It was during this period (1968) that compulsory education was extended from 6 to 9 years to raise the quality of fundamental education.

The second Reform period (*Self-running Science Education*) started with the establishment of a Science Education Centre in 1974, to specifically conduct a variety of research projects to improve the teaching and learning of science and mathematics, to develop and disseminate science and mathematics curricula for secondary

schools; and to develop instructional materials including audio-visual media for schools. Several policies and strategies were successfully implemented under the science, technology and society theme from 1974 to 1995, the free market science education theme from 1995 to 2002 and the integrated science education theme from 2002 till the present. Nine-year progressive and coherent teaching, and learning materials were integrated in addition to implementation of enquiry-based teaching strategy.

Taiwan had extensive extra-curriculum activities for science education ranging from weekend science camps for middle schools to basic science nursing senior high school projects; in addition to national and international science fairs, science odysseys, international science Olympiads (chemistry, physics, mathematics), PISA and TIMSS, International Science and Engineering Fairs (ISEF), etc, which were open to students from all levels. Taiwanese students had done well in international science and mathematics competitions and assessments [5]. The accompanying figure shows a track record of their success at the USA-based ISEF.

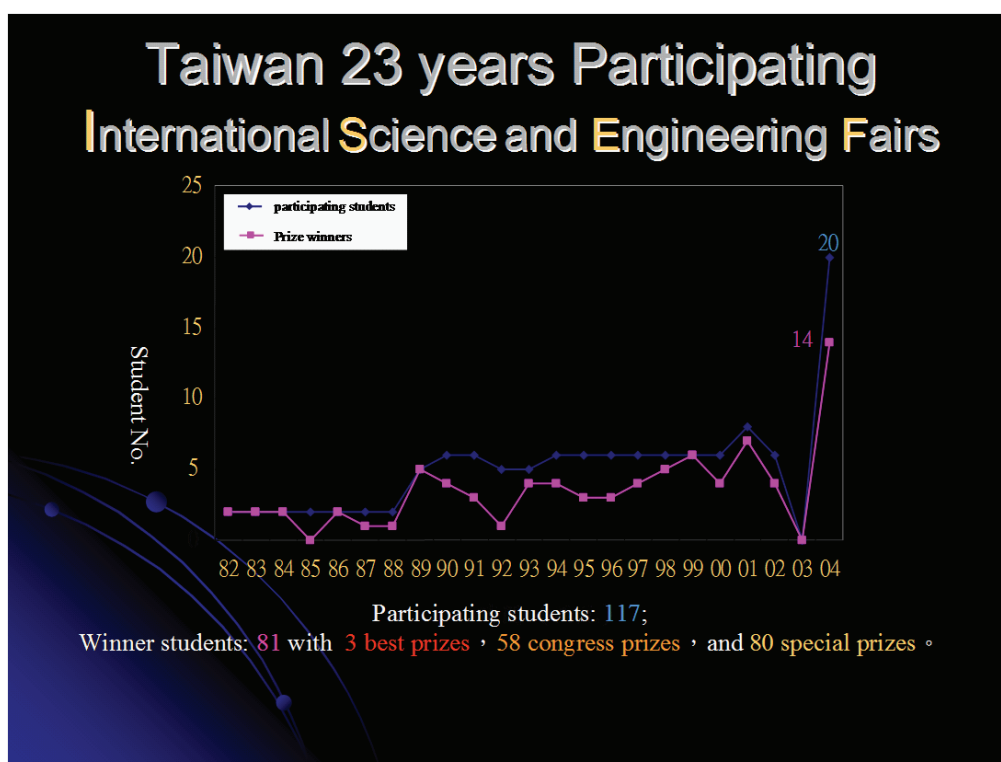


Figure 1. Track record of success for Taiwan participation at USA-based ISEF.

Notwithstanding their current technical success, Taiwan continues to promote science curriculum improvements that enhance the level of students' critical thinking and problem-solving.

EVOLUTION OF TEACHING AND LEARNING OF SCIENCE AND MATHEMATICS IN SCHOOLS IN MALAYSIA

Realizing the importance of the knowledge in science and engineering in advancing technology and hence the economy, our government had taken various steps over the years to accelerate the process of transforming the education system to meet the need of increasing demand of K-workers for the industries and business after an initial slow start in the 1980s. The emphasis on the repetition and memorizing method of education and curriculum of the 80s had given way to innovative ways of teaching where increasing use of technology in the teaching and learning of science was introduced in the 90s. PMR and SPM (based on KBSM) public examinations were also introduced during this period. In addition, the *Penilaian Kerja Amali (PEKA)*, a school-based science practical assessment

as an alternative of assessing the science process and manipulative skills of the students, was introduced in 1999. In fact under the 9th Malaysian Plan (RMK9), great emphasis was placed on increasing access to education and the quality of training at all levels. Steps had been taken to improve the academic achievements of students, particularly in rural schools, through better teaching quality, physical facilities and a learning environment.

In 2003 a bold step was taken by the government to convert the teaching and learning of science and mathematics in schools from Bahasa Malaysia (BM) to English (PPSMI). This change was implemented in stages starting from Year 1 in primary schools and Form 1 and Lower Six in secondary schools in 2003 with the conversion completed for all levels in the primary and secondary schools in 2007 and 2008, respectively. The rationale behind the implementation of PPSMI was that the richest sources for knowledge were all written in the English language. Equipping our students with the necessary language skills would enable them and ensure their ability to access and acquire the vast source of information and knowledge. It was hoped to increase the capacity for knowledge of our students under this new system which will educate and create the pool of knowledge-workers needed to achieve Vision 2020.

Under the National Education Development Master Plan 2006–2010 [6] launched by the Prime Minister, great emphasis had been stressed on the mastery of the Malay and the English languages, mathematics and science. Adequate trained teachers would be provided and 50% of primary school teachers would be university-trained by 2010. The major aim of the Plan was to produce students who are knowledgeable and skillful in science and technology and ICT. The four main thrusts of the Plan were to increase the access, quality and equity of education and to improve the efficiency and effectiveness of education management. Implementation strategies included revising school textbooks, improving integration of ICT in teaching and learning, expanding the smart school concept, revising the norms for teacher allocation, improving teaching and learning in science by providing more science teachers, laboratories, and teaching materials. In addition, contextual teaching and learning methods, new educational elements such as biotechnology and microelectronics to make the learning of science more interesting and relevant were introduced.

The measures taken were aimed at increasing the participation rate of students in science and mathematics in schools and to ensure that this was followed through into tertiary education. It was pointed out that students, in particular those from rural areas, were having difficulty in understanding terminology and the process of science and mathematics in English under the PPSMI system. On the other hand, many teachers still preferred traditional teaching approaches, despite exposure to new teaching methodology and were over dependent on commercial teaching materials, having little time and skills to prepare their own. Often qualified teachers in non-science options were asked to teach science subjects because of the shortage of trained science and mathematics teachers. The current education system in schools made teaching and learning too examination-oriented, to the extent that aspects of cognitive development were neglected resulting in a lack of higher order thinking skills in the students. The consequence of that was students finding the learning of science and mathematics boring and that in turn, influenced their performance in schools and subsequent participation in science and technology in later years.

In 8 July 2009, it was announced that the PPSMI system would be phased out in stages, starting from 2010; completely reverting back to BM as the medium of instruction in 2012. The reason for the change was the decline in grades in the UPSR examination results in science and mathematics, particularly in rural areas where students encountered difficulties in understanding the subjects because of the poor command of the English language. It had just been announced on 10 October 2010, that from 2016 the *Penilaian Menengah Rendah (PMR)* public examination for Form Three students would be replaced by a school-based assessment to be drawn up by the Malaysian Examination Syndicate. According to the news release “*a school-based assessment was found to be more suitable for the students in the country’s 7000 secondary schools. This assessment which has been carried out in 550 schools nationwide since 2008 was found to be the preferred choice of many*”. On the other hand, “*significant improvement will be made to the syllabus and papers of The Ujian Pencapaian Sekolah Rendah Examination*

(UPSR) for Year Six pupils”. The above were among the recommendations in a report on the proposal to abolish both examinations. This was part of the move by the government to restructure the education system which was perceived to be too examination-oriented.

WHERE DO WE STAND?

In this globalized world, knowledge changes very rapidly with time. Older content and technology become obsolete/irrelevant fast. The burning questions often asked are:

- Are our students equipped with learning skills that foster lifelong learning, for thinking and problem solving?
- Are the potentials for teaching and learning through ICT fully explored and exploited to create a competent K-workforce for the future?
- Are the skill sets imparted to our students relevant for the future workplace?
- Where are we now and have we achieved our targets?

Apart from some surveys carried out by individuals, reports on the effectiveness of the implementation of the science and mathematics education in schools did not seem to be available in the public domain. A search of the statistics on the performance and assessment of achievement of objectives of the education policies implemented did not yield any useful information. Most of the feedback was from workshops and seminars (briefly summarized below) and organized with a view of gathering information and feedback on the status of the education system in terms of teaching and learning of science and mathematics in schools. In an international study, i.e. the Third International Mathematics and Science Study (TIMSS) conducted on performance of Form 2 (Grade 8) students in 2007, it was revealed that on science subjects, Malaysian students scored 471 on average less than the international average of 500. Malaysian students scored 474 on average in Mathematics below the international average of 500, outperformed by students from Singapore, Korea, Hong Kong, Taiwan, Japan and 7 other countries [7].

In a paper presented at the CEDER Seminar at the University of Malaya (UM) in 2003 on a survey conducted in the state of Selangor on “Urban and Rural Primary Science Teaching” [8], it was found that rural schools had poor facilities and resources including a high turnover rate of graduate teachers. The standards of English of teachers and students alike were ‘extremely bad’ and the students found it difficult to catch up when moved to secondary schools in towns. However, achievement in sciences was weak for students from both rural and urban schools (see Table 1).

TABLE 1. ACHIEVEMENT IN SCIENCE FOR PRIMARY FOUR STUDENTS (SELANGOR)

Subjects	Urban (Mean score)	Rural (Mean score)
Science	53.61	47.27
Mathematics	59.73	49.88
English	51.08	41.62
BM writing	58.46	49.99
BM comprehension	64.43	58.97

Sample size: urban 43/244 (1569 students), rural 11/113 (442 students)
based on scores of 100 in mid year exam by each school [8].

It was further revealed [9] that students were rarely brought out of classrooms to study (nature walk, visits); contextual teaching and learning were lacking, thus connectivity between concepts learnt and the real world (problem-based learning) were seriously wanting. Laboratory facilities and activities were very often not available; current teaching aids did not help in critical and analytical thinking skills nor in inculcating science process and manipulative skills.

Similar observations were obtained from the findings of The Malaysian Science and Technology Convention, MASTEC 2007 [10], midway through the implementation of PPMSI, which found that the plans and policies on education were not systematically and seriously implemented while management practices were wanting. It was further hampered by frequent policy changes blurring directional paths. Often the infra-structure was lacking while the laboratory facilities and computer links were broken down or not operational to optimum levels. The curriculum was not relevant, cramped, rigid and heavy. The students were not excited to pursue science courses because they found them boring and not interesting. It was mentioned that there were very few qualified, committed and dedicated teachers. Finally there was an over-emphasis on completing the school syllabus by the teachers rather than ensuring understanding of the contents by students; the students often lacked self-discovery and articulation of ideas.

The Ministry of Education had set various targets for the Education Development Master Plan for 2008 [11] as shown in *Table 2*.

TABLE 2. IMPACT OF NATIONAL EDUCATION MASTER PLAN 2006–2010

Key performance indicators	Current 2005/6 (%)	Target 2008 (%)
Level 1 primary school pupils skills in reading, writing, arithmetic increased	92.3	95.0
Pupils requiring remedial programme decreased	7.7	<5
The need for tuition voucher reduced	100	80
Achievement gap narrowed among students	1–14 by subject	–20 of gap
Secondary students taking MPV increased in rural areas	5	8
Dropout rate reduced in rural areas	1.2 (1 ^o) 16.7 (2 ^o)	<1.0 (1 ^o) <10 (2 ^o)
Health of pupils in rural areas improved (attendance rate increased)	High	low
Quality and experienced teachers more prepared to serve in remote areas	Low	high

However, there has been no feedback or report whether these had been achieved.

From all indications and feedback, it would appear that the same issues and problems on the teaching and learning of science and mathematics in schools that had been identified decades ago were still plaguing us today. It really called for the full commitment and support of the relevant stakeholders to overhaul the whole

education system with respect to school management, policy implementation, effective delivery and assessment methodology, with a competent and dedicated teaching force. It was unlikely that we would be able to achieve the targets as outlined in the Master Plans for education if we did not take immediate action now.

ROLE OF ACADEMY OF SCIENCES MALAYSIA (ASM)

Under the ninth Malaysia Plan, ASM had been entrusted by MOSTI to manage a Science Education programme which focused on the role of scientists in increasing the quality of science and technology education in Malaysia. This programme has three main components, namely (i) interactive and innovation teaching with the learning of science through the establishment of learning stations or other innovative means that could make science teaching and learning more fun and interesting, (ii) establishing of a science portal and (iii) intellectual discourses taking the form of workshops, seminars, conferences and so on.

It was with these objectives in mind that a series of workshops involving relevant stakeholders in science and mathematics education (educators, scientists, policy makers and industry) were planned to be held throughout the various regions of the nation with the hope that the stakeholders would be able to share their firsthand experiences in the teaching and learning of subjects in science and mathematics in schools, identify any pertinent and specific issues such as curriculum, school facilities, delivery and assessment systems, rural versus urban school performance, commitment of teachers and the teaching service scheme, quality and relevancy of teacher training, if any, and make suggestions on ways that these could be tackled. The output from the workshops would go towards the preparation of a report/position paper which would then be submitted to the Ministry of Education.

With limited funds available from MOSTI and with no other financial resources forthcoming, ASM was able to put together two three-day workshops; the first was held in Shah Alam in February 2010 and the second workshop was held in Kota Kinabalu on July 2010 which focused on rural schools in Sabah and Sarawak. The Ministry of Education was very helpful in selecting and allowing expert teachers from primary and secondary schools throughout the country to take part in the workshops. They formed the largest group of participants and contributed actively to the deliberations on the issues and problems encountered by the teachers in government schools. Teachers from the private and international schools, MARA colleges and educators from the education departments of local universities made up another important group of participants of the workshop. Breakout sessions lasting one-and-half days in each workshop were held to address and deliberate on the following five specific topics:

- (i) Re-structuring of the curriculum and education system in the primary and secondary schools in Malaysia
- (ii) Intra-structure and info structure support for science and mathematics learning
- (iii) Policy, funding and implementation plans
- (iv) Improving training of teaching professionals, teaching profession service scheme; and
- (v) Future education trends: how to make learning of science and mathematics effective and fun.

In the first Workshop in Shah Alam, eleven papers were presented in areas related to the above topics by expert speakers who were familiar with the subjects. The topics covered the views on the teaching and learning of science and mathematics in schools from different education systems. It also covered the policymakers' and the educators viewpoints on the training of professional teachers. This was followed by a Panel Discussion where invited panelists gave further views on the above topics. As could be seen in Volume 2, 162 participants spent one-and-half days in the Breakout sessions to deliberate on specific issues on the teaching and learning of science and

mathematics in schools. We believe that this was the first time that teachers from four different education systems (government, private, international and MARA schools and colleges) were brought together to exchange views, ideas and information. In addition, we had the educators from the universities and the policy makers from MOHE, MOE and MOSTI sitting in listening to the views of the teachers, who were the last link in the supply-chain of the education system. This direct communication should ensure that the true picture of how well and effectively the education system was implemented on the ground and what could be done to further improve the implementation was captured by the relevant stakeholders immediately.

In the second Workshop in Kota Kinabalu, twelve papers were presented by expert speakers on topics such as inquiry-based learning. The topics covered the views on the teaching and learning of science and mathematics in schools from rural areas. As could be seen in Volume 3, 129 participants spent one-and-half day in the Breakout sessions to deliberate on specific issues on the teaching and learning of science and mathematics on rural schools in Sabah and Sarawak.

MAJOR ISSUES AND OBSTACLES/GAPS THAT HINDERS ACHIEVEMENT OF THE NATIONAL EDUCATION MASTER PLAN

Curriculum and Education System in the Primary and Secondary Schools

A general comment of the curriculum on science and mathematics by the participants was that the content was of comparable standards with those of the advanced countries. However, the teachers felt that there were too many topics to be covered and there was not enough time to complete them effectively. There was an obvious lack of emphasis on the element of imparting higher order thinking skills. The curriculum lacked ‘continuity’ amongst the various levels. The teachers highlighted that it was at the implementation stage of the curriculum at the school level that problems arose and that it needed improvement in the delivery and assessment methods. Some issues had their root cause in the teachers themselves, in terms of their competency in understanding the contents of the curriculum and in diligently carrying out the methodology and procedures as required under the system. The other issues had to do with the lack of physical and teaching facilities in the schools. A lot of these issues were related to the locations of the schools, whether in rural or urban surroundings and the facilities and ambience at those locations; the quality of the students and their family backgrounds, the teachers posted there and their initiatives and commitment. Many teachers found that they were unable to complete the syllabus in time while simultaneously ensuring comprehension by the students. Often the students were taught and spent more time to answer past yearly examinations questions rather than teachers directing their effort on making learning interesting and eliciting understanding of the subject by the students through thinking skills methodology.

It was pointed out that there was a serious lack of reading materials and references in science and mathematics in Bahasa Malaysia. The academic quality of schools text-books was also found wanting. A comparison was made that the Japanese and the German were very fast in publishing translated titles of English books in science and mathematics to allow their students and populace easy and speedy access to this knowledge source. In passing, it was mentioned the issue was particularly acute at the tertiary level where very few translated titles of texts and references on science subjects of recent and current interests were available in Bahasa Malaysia.

The diverse background and low ability of the students made the teaching and learning of science and mathematics challenging for the teachers.

In addition, there was too much to cover in the syllabus in the short allocated time.

There were too little real life application examples and a shortage of calculation type of questions in physics.

There was insufficient course material to complete the syllabus.

The assessment method was too examination orientated, thinking skills were not assessed, examination questions were too predictable, and the multiple choice questions in mathematics for PMR/SPM were irrelevant.

Practical skills were not taught (no laboratory classes) and implementation of PEKA was ineffective. Assessment of PEKA was ineffective. Laboratory practical manual was incomplete.

The practical component was not given weightage under PEKA.

The topic on thinking skills was in the curriculum but the teachers were NOT utilizing and not teaching it.

Thinking skills were apparently not assessed in the present assessment system by examination.

The command of the language (English) of some of the teachers was poor and those teachers found it difficult to express effectively the process of science and hence make an effective delivery of the curriculum content.

Infra-Structure and Info Structure Support for Science and Mathematics Teaching and Learning

The teachers felt that they were not so IT savvy and needed more IT training to make them competent in teaching techniques requiring the knowledge of IT. Many teachers were not fully able to use software effectively because of insufficient IT background and training. It was felt that the IT technical support at the school levels was seriously lacking, coupled with poor maintenance and poor internet accessibility.

Very often Science Rooms were NOT available in primary schools, hence only limited experiments were conducted in the classrooms and often there were no hands-on activities for the students with the result that students were not familiar even with basic science apparatus.

In secondary schools in Sabah and Sarawak, mathematics/ICT laboratories were often not provided for and science laboratories were old, small and overcrowded and there was a serious lack of consumables such as chemicals or they were expired materials. Hence laboratory safety was often compromised. Many students did not get to have any hands-on experience to develop their manipulative skills. However, in Peninsular Malaysia and in urban areas in Sabah and Sarawak, schools are provided with well-equipped laboratories (See *Plates 1, 2 and 3*).



Plate 1. Science Laboratory, SMK Kompleks Uda, Johor:



Plate 2. Science Laboratory, SK Dumpar, Muar, Johor:



Plate 3. Science Laboratory, SMK Pujut, Miri, Sarawak.

It was highlighted the hardware (PC, LCD and notebooks) was frequently outdated, malfunctioning and even without functioning batteries. There was no regular maintenance and upgrading of equipment, while not all schools were provided with computers.

The calculators provided were not reliable and some of the functions were not even practical (e.g. graphing). Many teachers are not using the ‘teaching aids’ in class provided by local suppliers because they needed time to learn them.

The teachers were NOT trained to make or prepare ‘teaching aids’ themselves.

The teachers’ poor ICT competency and proficiency in English had a negative impact on their initiatives to access the vast amount of knowledge in the public domain of the worldwide webs (www) which are dominated by the English language to complement their teaching materials and knowledge enhancement.

The second Workshop for teachers posted to rural schools in Sabah and Sarawak highlighted the plight of the schools. Those schools in the interior (remote and isolated) were particularly lacking in terms of basic facilities such as clean water and electricity supplies, poor transportation, living amenities and communications. For a sizable number of them, great effort was needed to reach the schools from some accessible point on the fringes of small towns. The journey usually started on jungle roads, then on foot overland (foot-paths) and boat rides along rivers or different combinations of them. Several accounts had been given that it took 2–3 days at times to reach the destination in the interior (isolated) (*Plate 4*).



Plate 4. Journey to school through jungle track, SK Saliliran, Nabawan.

Upon arrival, the teachers often found the school and teacher housing in a deplorable state (*Plate 5*). There was an obvious pressing need for providing decent teacher's quarters and for improving the quality of current existing quarters. Sanitation and the minimum hygiene standards of a flushing toilet was a luxury. The school facilities such as science rooms, computer rooms, internet connection and supplies were sad to say, most of the time not available. The very basic amenities of clean water and electricity were sometimes not provided or the supply was intermittent. Of course, even rudimentary health and medical care was absent. By then, most of the teachers would be already demoralized and devastated and wanted to be moved out. This had resulted in a high turnover rate of teachers posted to Sabah alone (1200 per year). In a small-sample survey conducted during the second workshop [See Volume 3], close to 60% of the teachers said they had served less than 10 years in Sarawak, whereas the percentage was 40% in Sabah. These numbers indirectly reinforced the relative high turnover rate of teachers in the states.



Plate 5. Teacher's quarters, SK Inandung Keningau, Sabah.

These isolated schools (*Plate 6*) were often cut off from civilization in the sense that without electricity and without proper access roads or waterways, there was practically no convenient means of regular communication with the outside world, in particular telecommunication. Not only telephone lines were not available but also hand-phones which were ubiquitous in this modern era were out of the operation range. It was thus understandable why teaching and learning through the electronic media using the ICT approach could not be implemented there in the rural setting.



Plate 6. School without electricity supply, SK Wasai, Tuaran, Sabah.

The teachers, like the rest of the people staying in those areas, had no choice but to travel to the nearest town during weekends to get connected. These added to the woes that were plaguing the already deplorable plight of the teachers. One could thus understand the reason why teachers did not want to be posted to Sabah and Sarawak, fearing that once they accepted the posting they would be stuck for a while in that area. That was the feedback from teachers who participated at the Second workshop.

A direct consequence arising from the reluctance of teachers to serve in the rural schools in Sabah and Sarawak was that good teachers, in particular trained science and mathematics teachers, were difficult to get and many of the schools were lacking in science and mathematics option teachers, hence the quality of teaching and learning of science and mathematics was greatly affected. It was lamented that the non-option teachers tasked with teaching science themselves serves had only often a poor understanding of the content and the science process itself. The quality of teaching could easily be imaged. The poor facilities or complete lack of it, the isolated nature of the schools and accompanying difficult accessibility coupled with the lack of trained science and mathematics teachers had all contributed to this overall decline in learning efficiency of the students. This was reflected in the poor performance of the rural school students compared to those from the urban schools in the Sarawak state. **In fact in a separate survey published way back in 2005 for rural and urban schools in Selangor, it was reported that the facilities in the rural schools in Selangor were nowhere near those in urban areas. Teachers were already unwilling to be posted to these rural schools. What it meant was after all these years, the situation had not improved. The situation in Sarawak and Sabah would naturally be a lot more serious and the gap in performance of the rural and urban schools was expected to be even more bigger in view of the size of rural population.**

Policy, Funding and Implementation Plan

The current big student to teacher ratio per class in many schools had made effective delivery and teaching difficult. Class management and control was another big issue. Individual attention for students could hardly be

achieved. That also posed constraints on the already limited teaching resources in the school. Teachers were often overburdened with clerical and administrative work. This left less time for the teachers to prepare lessons and laboratory work, thus further aggravating the quality of delivery and teaching.

Not all schools were allocated trained science and mathematics teachers. Non-optionists were required to stand in and teach these subjects. Students often could not relate what they have learnt to real-life examples and therefore lost interest in learning itself. Higher order skills and manipulative skills were often not covered in class. Assessment did not cover all the elements of learning, in particular higher order thinking skills and manipulation skills. School project work and laboratory work were NOT given weightage in major examinations. Only limited funds were allocated for project work and that curtailed teachers and students from conducting science and mathematics projects and participating in them. Such activities encouraged creativity and thinking skills. The practice was contrary to the objective of promoting the learning of science and mathematics in schools and in achieving the 60:40 ratio of science to arts student enrollment for our schools and universities.

The policy of reverting to the teaching of science and mathematics using Bahasa Malaysia in schools should be reconsidered, in so far as Secondary schools (and onwards) were concerned. Science and Mathematics in Secondary schools onwards should be taught in English. This was because English was an international medium for not just instruction but also communication in the world of business, finance, science and technology in a global market in regional and international dealings. With the advancement in computer technology (and in the fields of medicine and health, agriculture, biodiversity, biotechnology and so on), the transmission of knowledge was mainly in English. To be recognized internationally, researchers had to publish their papers mainly in English in peer-reviewed journals. The teaching of Science and Mathematics in English was needed to be pursued into the Matriculation and University years to ensure continuity and strengthening in English.

That would certainly help alleviate and hopefully solve the issue of lack of reference materials in Bahasa Malaysia, in particular in tertiary education mentioned earlier in Curriculum and Educational System in the Primary and Secondary Schools. Indirectly that would ensure that new teachers recruited and trained for the future were themselves proficient in the English language, able to tap into the vast resources in English available in the internet and make effective delivery of the latest knowledge in the classrooms and hence help effectively build up long-lasting interest in science and mathematics in the students.

Improving Training of Teaching Professionals, Teaching Profession Service Scheme

The current one-year Post-graduate Education Diploma Program by universities (DPLI) and Teacher Education Institutes (KPLI) were not matching the terms of the Degree and option. It was felt that the trained teachers were not competent enough and lacked the confidence to teach the subject. An imbalance in weightage on subject content and pedagogy techniques was highlighted and a review of the training programme was deemed necessary and timely. Since teachers were entrusted to educate the future generations, it was important that only the best applicants/graduates who had the passion and were committed to the teaching profession as a career were admitted to undergo the training to become teachers. The many short training programmes conducted during school holidays, for primary schools and for other teachers and those conducted by Education Faculties in universities need to be reviewed for their effectiveness and relevance.

The service scheme for the teachers had no doubt provided various modes for promotion, career advancement and professional recognition. However, in view of the tight schedule of the curriculum, too many topics in the contents and the need to keep up with new teaching techniques and technology had cause some teachers to be under stress resulting in personal health problem.

Future Education Trends: How to Make Learning of Science and Mathematics Effective and Fun

Most students found the learning of science and mathematics in schools as NOT interesting. Factors contributing to that were that not all teachers were the best choices for the profession in terms of academic qualification and commitment, time constraints (teachers had to rush through the subjects in the limited time allocated for the subject); very large classes and the constraints of laboratory space; lack of laboratory facilities (science rooms); insufficient teaching materials in primary schools; school textbooks which lacked elements of creativity and innovation; inability of teachers to use the latest technology resources in class and lesson; too much emphasis on chasing after A's in major public examinations and neglected aspects on understanding of the subject and conceptions, development of thinking skills and manipulations skills which form an integral part of a holistic education.

It was envisaged that ICT would play a much bigger and increasingly more important role in the future trend of teaching and learning of science and mathematics. Fun contextual learning and knowledge acquisitions using ICT technology would be even more prevalent in time to come. Many of our teachers would need intensive training on ICT techniques and software/ courseware usage to enhance their teaching quality and delivery efficiency. Several Web-based Inquiry Science Learning sites were available (for example Paper 8: *Implementation of Inquiry-Based Visualization- Rich Curricula in Taiwan*, by Dr Hsin-Yi Chang, Taiwan, See Volume 3 of this Advisory Report), in addition to hands-on activity-based teaching methodology. These were good examples of methodology that could be further explored to make the teaching and learning of Science and Mathematics more fun in the classrooms.

The government should reconsider reinstating the policy of teaching of Science and Mathematics in English, at least for Secondary schools onwards. This was clearly seen as the prevailing trend in not just ASEAN countries but also in other newly-emerging countries. The success of Taiwan and the other newly-emerging economies of China and India as well as nations in ASEAN were due to their using English as the preferred medium of instruction in secondary schools to universities. As an example, the President of the Republic of China, HE Ma Ying-jeou, stated at the Common-Wealth Economic Forum held in Taipei City on 10th January 2011 that Taiwan was pursuing a policy of English being the medium of instruction in its universities as they want to forge Taiwan into an Asia-Pacific centre of higher education [12]. Taiwan's plan was for its schools to gain the upper hand in terms of attracting students from that region if they could succeed in setting up all-English curriculums. There were already 30 universities in Taiwan that were ideally suited to offer English-language curriculums.

The reinstating of the policy would ensure that Malaysia was not left behind in the international arena and would as well catapult Malaysia into the world stage ensure that Malaysia's rights were safe-guarded when it came to negotiating international and regional treaties, agreements and memoranda, including the important areas of international trade, national security and defense.

Basic Amenities — Clean Water, Electricity, Transportation, Telecommunication and Electronic Media

It was acknowledged that steps and measures had been taken to alleviate the extreme poor state in affairs of the schools in Sabah and Sarawak and to improve the quality of teaching and learning of the students. That was just a drop in the ocean of the actions that needed to be taken to bring the standard of living and hence the quality of education of the States of Sabah and Sarawak to be anywhere near those of the urban schools in the Peninsular. However, judging from many pressing issues involving the provision of very basic infra-structure of clean water and electricity supplies, the necessary road and water transport support system for easy access to these interior and isolated areas, followed by the setting up of connectivity through electronic media and telecommunications and the necessary healthcare for the well-being of the students, teachers and the community alike, it was clear that it would take time, money and the commitment of the relevant authorities to move this. Those are major issues of a

mammoth magnitude transcending many ministries and hence should be better tackled at the national level. **Some of those issues that need attention and improvement had in fact been embedded in the New Key Results Areas (NKRA) unveiled by the Prime Minister himself in September 2010 under the ambitious Malaysian Government Transformation Programme under the Heading ‘Improving Student Outcomes’.**

Diversity of Local Cultures and Languages in Rural Sabah and Sarawak

Geographically, Sabah with a land area of 73,620 km² (almost the same size as Peninsular Malaya) is the second largest state in Malaysia, just after Sarawak; 124,450 km². Since about 70% of the land in Sabah was hilly and mountainous, 80% of the population were rural. According to the information by JPN, the number of schools in Sabah located in rural setting or at the fringes of towns is shown in *Table 3*. About 89% of the schools came under the definition of rural schools for Sabah alone. It was therefore not surprising that almost 70 % of the students were from rural areas. The dropout rate of the students from the rural schools was twice that of the national levels. This could be closely linked to the social economical conditions of the rural population. It had been reported that 23% of the population in Sabah lived below the poverty line with 6% of them classified as hard-core poor. The situation in Sarawak is shown in *Table 4*. In fact, the number of schools in the rural areas and those considered as isolated, were even higher in Sarawak. It can be seen from these two Tables that the number of secondary schools constitute less than 12% of the total number of schools in the respective state. One was tempted to deduce that many of the students did not proceed to secondary schools in the state after finishing six years of education.

TABLE 3. DISTRIBUTION OF SCHOOL TYPES IN SABAH

Location		Secondary schools	Primary schools	Total
Rural	Rural	135	916	1051
	Small town	19	61	80
Urban	Urban	44	76	120
	City	10	16	26
Grand total		208	1069	1277

(Source: Nuri Udin 2010)

TABLE 4. DISTRIBUTION OF SCHOOL TYPES IN SARAWAK

Location/ Level	Urban	%	Rural	%	Isolated	%	Total
Primary	184	14.54	649	51.26	433	34.20	1266
Secondary	65	36.52	103	57.87	10	5.61	178
Total	249	17.24	752	52.08	443	30.68	1444

(Source: Samsudin Drahman, 2010)

The high student dropout rate was alarming and would certainly bear on the education level and the skill set of the youths in the state and impact directly on their future employability. That could further derail the plan by the government to create a high-income society under the New Economy Model (NEM), particularly in Sabah and Sarawak. In a recent report by the Organization for Economic Co-operation and Development (OECD), it was recommended that extra university places should be funded as a way out of recession and unemployment [13]. An adequate supply of human resource with the appropriate education level entering the job market was essential to ensure a competitive workforce for survival in a global economy. This referred to a high proportion of a skilled and professional workforce with minimal tertiary education in the advanced economies. They obviously had to draw on the cohort of quality eligible secondary school leavers to feed the universities and professional colleges. It was opined that a larger numbered, employed, skill /professional workforce contributed higher tax revenue for the government and, better health and participation in society. That in turn provided a conduit out of recession. As the higher-paid jobs were taken up by the growing number of graduates, those leaving schools with poorer qualifications and missing out of gaining a place in institutions of higher learning were facing a very bleak future indeed. It was clear that quality school education was the foundation upon which a skilled workforce based on science, engineering and technology was built. **A high-income society depended, first and foremost, on an education system that worked effectively and inclusively for all schools, rural and urban alike.**

One additional factor that the teachers brought forth was the diversity of the ethnic groups in Sabah and Sarawak that they had to cope with. With as many as 32 different spoken languages used by the different local inhabitants, mastering even a single one for a working conversation with the local was often NOT easy, let alone using one to communicate for the purpose of teaching and imparting knowledge to young children. New teachers who arrived at the schools for the first time often faced communication problems with the students. A similar situation was encountered in Sarawak, where officially there were 40 sub-ethnic groups each with its own distinct language, culture and lifestyle. However, some of the ethnic groups in Sarawak were larger in contrast to those in Sabah, where the diverse ethnic groups were usually smaller. It had been strongly suggested that the schools or JPN provide some introductory courses on local languages and cultures to the new teachers who were posted to these schools to assist them to adapt faster and better to the new environment.

RECOMMENDED STRATEGIC MEASURES TO ADDRESS PERTINENT ISSUES

The feedback from the workshops clearly show that the policies of the government over the years have not yet had the effect of driving up the participation and performance of the students in science and mathematics to the desired extent. The crux of the issue appears to be the lack of an effective implementation of the policies at the school level and the lack of a national body to oversee the co-ordination across ministries on all issues affecting the implementation of the policy at every level. ASM has drawn up two (2) strategic measures targeting specific stakeholders to address and ensure the successful implementation of the policies put forward by the Government to raise the standard of science and mathematics in all schools, both urban and rural.

It is hoped that by the implementation of the strategic measures and action plans in this position paper by the policymakers and stakeholders of the respective authority, the issues and problems identified and deliberated upon could be resolved placing the Education Master Plan on track to achieve its target of creating a competent knowledge-workforce for the future workplace.

Strategy 1. Establish a National Education Council (NEC) — MOE

The National Education Council (NEC) would be modeled after the National Water Resources Council, National

Land Council, the National Forestry Council and the National Spatial Planning Council, and would bring State and Federal stakeholders together to engender a consensus on infra-structure and info-structure issues affecting education, including spatial planning respectively.

The role of the Council would be to develop relevant policies, strategies and conduct regular reviews as the main stakeholder and driver for all education infrastructure- and infostructure-related projects throughout the nation.

The Council would be chaired by the Prime Minister with members such as the Menteri Besar/ Chief Ministers of all the states and others drawn from the relevant Ministries such as Ministry of Education, Ministry of Works, Ministry of Green Technology, Energy and Water, Ministry of Science, Technology and Innovation, Ministry of Finance, Ministry of Higher Education, Economic Planning Unit, various stakeholders connected with education and employment such as Ministry of Human Resources, Federation of Malaysian Manufacturers (FMM), Malaysian Association of Private Colleges and Universities (MAPCU), Council of Vice Chancellor, National Professors Council (NPC), National Union of the Teaching Profession Malaysia, UNIK, National Parents-Teachers Association, Academy of Sciences Malaysia (ASM), and with the Ministry of Education as the Secretariat.

Strategy 2. Establish State Education Committees (SEC) — MOE

These committees would be at the political level of Government, allowing coordination among the various agencies that are involved in the siting, construction (with necessary infrastructure in place) and management of schools. The model for this would be State Agriculture Committees or State Industrial Committees that are headed by Menteri Besar/Chief Minister, State Executive Councilors or State Ministers. Members of these Committees would be drawn from the corresponding agencies as at the Federal level.

The role of these Committees would be in implementing, monitoring and evaluating the implementing efficiency and effectiveness of the policies, strategies and actions at the state level as developed by the NEC.

In implementing these strategies, ASM is proposing eight (8) action plans to implement the strategic measures. All of these action plans are considered important. However, if some prioritization needs to be incorporated, then the following prioritized list should be used:

Action Plan 1. Enhancing the Training of Professional Teachers — MOHE/MOE

- The selection of teachers for training should be based on academic merit, aptitude and attitude. Only the best scholars should be admitted to become teachers.
- Lengthen the training duration for the DPLI and KPLI courses from 1 year to 2 years.
- Provide feedback and evaluation for relevance, effectiveness of teacher education training programmes to universities and IPGs.
- Secondary school science and mathematics teachers to specialize in one subject only to ensure their expertise.
- To institutionalize a training of trainers (TOT) programme for and by excellent teachers to share their experiences, expertise and guidance for the pre-service and in-service teachers in Teacher

Education College/Universities. This represents a value-add element to the professional educational programme.

- To improve the language skills of the teachers, especially in the command of English.
- To provide sufficient ICT training in Professional Teacher Education programmes.
- To develop and provide training on inquiry based learning methodology for teachers
- To make our all our future teachers ICT savvy and competent
- To introduce emerging fields briefly into subject content e.g. nanotechnology and biotechnology.

Action Plan 2. Improving Teachers’ Service Schemes — MOE/JPA (Human Resource Management Division)

- To improve opportunities for teachers to be promoted through different modes.
- To provide better pay schemes and incentives to attract the best to join the teaching profession.
- Science and maths teachers should also be emplaced on a higher entry point to encourage more good science and maths graduates to take up teaching as a career.
- To provide promotion schemes for teachers with higher degrees.
- To provide financial support for teachers to attend and present papers in conferences and seminars.
- To provide special training programmes, included IT, Pedagogy, Creative and Innovative best practices for teachers to improve their performance and quality of delivery.
- To organize seminars and conferences on teaching and learning of science and mathematics at the state and national level. This can serve as platforms for professional knowledge sharing and exchange of ideas and experience.
- To introduce study trips, exchange programmes to visit schools overseas with proven innovative and creative teaching and learning systems for upgrading and benchmarking.
- To provide counseling and motivation programmes for problematic teachers.
- To re-introduce the scholarship system of educating science and mathematics teachers at the best teacher education institutions/universities overseas.

Action Plan 3. Review and Institutionalize an Inquiry-based Science Education Science Curriculum to Meet Future Needs — MOE (Curriculum Development Division)

- Cut down the content of the science and maths curricula by at least 30% (as has been done by Singapore) to ensure that Inquiry-Based Science Education (IBSE) as well as Higher Order Thinking Skills (HOTS)

and Integration of ICT can be implemented effectively in the classrooms. This gives more time for the teachers to carry out problem-based learning and other methods; and not just teach for the exams.

- To start teaching science at Year 1 with same number of periods as allocated for maths. The new curriculum to be implemented should have science as a separate subject at Year 1 – 3.
- To revise and remove some sections of the curriculum for better implementation and to develop students who are analytical, innovative and critical in their thinking in line with global trends.
- To have more cross-referencing among the science subjects and among the different levels so that the curriculum is more coherent and has more continuity from primary to secondary to matriculation levels.
- More refresher courses for teachers to upgrade on curriculum contents, teaching methodology and ICT knowledge.
- The Curriculum Development Centre should look into revising the curriculum to make it more coherent, less overlapping, to make it “fun and interesting”, maintain continuity across different levels, incorporating more real life examples, increasing more time for delivery of Additional Mathematics and Pure Science subjects.

Action Plan 4. Improving Assessment Methodology of Science and Mathematics Subjects — MOE (Examination Syndicate, Examination Council)

- Re-introduce practical exams but give more weightage (perhaps 30% of total marks) and make them school-based.
- All students who leave secondary school must be involved in one science and one maths research project before they are allowed to graduate from high school to encourage R&D activities amongst students.
- Assessments need not be based on Bloom’s taxonomy only; and assessments must not only be summative but more formative (assessment for learning) and diagnostic as well to improve teaching.
- With the new curriculum to be implemented having science as a separate subject at Year 1 – 3 (see Action Plan 3), impose a minimum pass in science and mathematics before moving to Standard 4 in primary schools as a summative assessment at Year 3 before they go on to Year 4 at the primary school should not be encouraged.
- To re-introduce practical examination for Pure Science at the SPM level.
- To train teachers on how to develop questions according to Bloom’s Taxonomy; to promote more problem-solving questions.
- To promote more learning on outcome-based examination.
- To review assessment methods at all levels so thinking skills and practical skills are assessed and counted in the performance.

- To review assessment methods to incorporate aspects of higher order of thinking skills and manipulative skills.
- The Lembaga Peperiksaan Malaysia should look into including more questions to assess the higher order thinking skills of students in the major public examinations.

Action Plan 5. Improving the Quality of Education Training and Delivery System to Make the Learning of Science and Mathematics more Fun and Interesting — MOE (Teacher Education Division)

- Teachers must incorporate more real-life applications and examples to make learning more fun and interesting.
- To synergize the use of ICT and conventional approaches to increase students’ interest in science.
- To enlist the help of NGOs, professional bodies, ASM, Petrosains, MNCs and GLCs to support innovative and creative projects in schools.
- To organize more classes/activities outside the class-rooms, teach them to be aware of their surroundings and real life applications such as via hands-on activity-based teaching methodologies.
- To develop hands-on teaching aid methodologies that are innovative, creative, fun and interesting to enable students to observe, think and deduce (conclude).

Action Plan 6. Reinstate the Policy of Teaching of Science and Mathematics in English From Secondary Schools Onwards — MOE (Curriculum Development Division)

- To teach Science and Mathematics in English from Form 1 onwards through into the University stage.

Action Plan 7. Improving the Infra-Structure and Info-Structure Support - MOE (Educational Technology Division and Procurement and Asset Management Division)

- To provide more purpose-built science laboratories in secondary schools with adequate equipment for hands-on science experiments and projects.
- To provide purpose-build “science rooms” in primary schools for conducting practical classes
- To have well-equipped and **functional** computer rooms with internet-access capability, particularly in rural schools.
- More training and refresher courses on IT awareness and knowledge for the teachers, specifically on the applications of the softwares/coursewares provided by the government.
- Need regular maintenance and upgrade of hardwares provided to schools.
- Need specific guidelines on the types and models of calculators permitted by MOE for use in schools and examination halls

- Teachers would like to have training on how to use and make ‘teaching aids’, IT soft skills, creativity and communication at JPN level.
- To explore synergy in ICT technology and teaching materials/aids improvisation by technocrats and provide training for teachers to acquire this skill
- To provide findings from R&D to the teachers to support their teaching activities
- To set up R&D unit on ‘teaching aids’ development in Ministry
- To establish ‘teacher support system’ for teachers to exchange and share knowledge, as has been done in New Zealand where they have people at the School of Education in universities assigned as Teacher Advisors who work with teachers to help in improving teaching and learning, spending much of their time in schools and help teachers with making teaching aids and sharing good practices. Some of our IPG lecturers can also be assigned full-time as Teacher Advisors.

Action Plan 8. Improving Education and School Management — MOE (Public School Management Division)

- Adequate number of teachers (science and mathematics) should be allocated to schools where they are most needed.
- To lessen the administrative load of teachers and allow them to concentrate more on teaching
- A support system should be provided to enhance the knowledge and skills of non-optionists teachers if they are still needed to continue with teaching of science and mathematics, in the worst case scenario.
- To reduce the students number per class to a more manageable level so that quality of teaching can be improved and higher learning efficiency can be achieved.
- To provide administrative support for teachers and laboratory assistants in primary schools.
- To provide relevant ICT training to teachers or at least basic ICT knowledge and appreciation, usage of software for maximum impact on teaching.
- To attract the best scholars who want to make teaching their career for the teaching profession.
- To stop giving scholarships to straight A students only, so as to discourage rote learning for the exams and parents paying hefty sums for tuition classes. Scholarships should be given to students who not only perform academically but also take part in extra-curricular activities and community services.
- To request the media to stop highlighting all the straight A students when the results come out but should highlight students who take part in science fairs and congresses etc.

CONCLUSION

Two strategic measures have been drawn up for the NEC as an overall stakeholder to drive the national education policy and ensure its effective implementation over the whole nation, in particular Sabah and Sarawak. The eight Action Plans outline very clearly the actions to be taken by the various stakeholders at the state and school levels. The numerous problems of implementation at the school level will have to be resolved speedily through trans-department linkages and coordination provided under the NEC and SEC. This would ensure the effectiveness of delivery and concurrent effective learning by the students. It is envisaged that the curriculum for the public schools which is currently under review will be more coherent, relevant and have better flow through the different levels. The training of professional teachers by our training institutions needs also to be reviewed and upgraded to ensure that the teachers produced are equipped with the latest teaching methodology and language skills and are competent for the job. In addition, more stringent selection of the best candidates for the teaching profession must be strictly enforced. The infrastructure and info support for schools and teachers need to be beefed up to meet the increased demand on ICT technology for effective and quality delivery and, fun and interesting learning by the students. The education system is supposed to provide holistic education to our students who are to become the K-workers of our nation, in addition to leading the nation in the years to come.

It is hoped that with the implementation of the strategic measures, the nation is on track to create the relevant competent knowledge-workers for the future economy in line with the New Economy Model on high-value economy and inclusiveness.

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APPENDIX

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