IIEP research and studies programme

The development of human resources: the provision of science education in secondary schools

Insights into science education: planning and policy priorities in Malaysia

edited by
Sharifah Maimunah bte Syed Zin
Keith M. Lewin

International Institute for Educational Planning

Ministry of Education
Malaysia

Insights into science education: planning and policy priorities in Malaysia

This study has been prepared under the auspices of the project on 'Planning science education provision in general secondary schools' directed by Françoise Caillods.

Insights into science education: planning and policy priorities in Malaysia

Edited by

Sharifah Maimunah bte Syed Zin
Keith M. Lewin

International Institute for Educational Planning, UNESCO

Educational Planning and Research Division
Ministry of Education, Malaysia

The views and opinions expressed in this volume are those of the authors and do not necessarily represent the views of UNESCO or of the IIEP. The designations employed and the presentation of material throughout this review do not imply the expression of any opinion whatsoever on the part of UNESCO or IIEP concerning the legal status of any country, territory, city or area of its authorities, or concerning its frontiers or boundaries.

The publication costs of this study have been covered by a grant-in-aid offered by UNESCO and by voluntary contributions made by several Member States of UNESCO, the list of which will be found at the end of the volume.

This volume has been typeset using IIEP's computer facilities
and has been printed in IIEP's printshop.

International Institute for Educational Planning
7 - 9 rue Eugène-Delacroix, 75116 Paris

IIEP/jn

Foreword

One of the major challenges facing human-resource planning is dealing with the uneven level of technological development in different countries. We have witnessed a huge scientific and technological explosion in recent decades; but not all societies have been equally affected by this process. Yet the ability to master and apply science and technology is indispensable to the process of modernization and development of economies.

As early as the 1960s, developing countries were aware of this fact and embarked on programmes to support the development of science education at secondary and higher education levels. Much has been achieved and almost everywhere the number of pupils and students enrolled in science courses has increased. However, the impact of these programmes has not always reflected the high expectations associated with them and the lack of science-trained personnel at higher- and middle-levels continues to hamper the socio-economic development of many countries.

The reasons for this state of affairs are many: well-trained and motivated science teachers have remained in short supply in most countries; curriculum reforms have not been implemented as planned, either because the necessary resources have not been available or because it takes time for schools and teachers to change their habits and teaching methods. All these problems have been aggravated by lack of co-ordination between the numerous administrations and institutions concerned with science education, by insufficient planning and by bad management of existing resources.

The overall objective of the IIEP research project on planning the provision of science education is to appraise the state of secondary school science in a range of developing countries and to reinforce national capacities to plan and manage this education in ways which will contribute to human resource development. A number of studies and monographs have been undertaken under this project, directed by Françoise Caillods, which specifically aim at establishing the condition of science education at the secondary level in countries at different levels of economic development, developing techniques and indicators of use to the planner in assessing science education provision and identifying strategies for providing science education in a more effective way.

The present case study is on Malaysia, one of the newly industrializing countries which has benefited from a very rapid rate of economic growth. The country recognized long ago that modernization and rapid industrialization depended on the development of science and technology. In a new policy document called Vision 2020, it fixes itself the objective of full industrialization by the year 2020. Attaining such an objective requires, among other things, training the necessary technical and scientific personnel. It also requires the existence of a flexible labour force which has received a broad based education at primary and secondary level, including solid foundations in science and mathematics.

The development of education in general, and the development of science education in particular, has been impressive in Malaysia since its independence. With respect to the latter, as early as 1960, an explicit commitment was made to expand and improve its quality. The teaching of science was made compulsory at all levels, from primary to upper secondary education. Curriculum reforms were enforced which aimed at introducing more pupil-centred approaches and at emphasizing problem-solving skills. Special science residential schools have been created, with a view to increase participation and achievement in science amongst rural and educationally disadvantaged students. All of these policy interventions have been introduced sufficiently long ago for their effect to be assessed. The new curriculum, which has been introduced in 1991 at lower- and upper-secondary level, also needs to be monitored.

This study, which has been undertaken jointly by the International Institute for Educational Planning (IIEP) and the Educational Planning and Research Division of the Malaysian Ministry of Education aims at taking stock of achievements to date in science education, at appraising current issues as well as designing a methodology for monitoring progress. It identifies a number of problems. Many of these – the decline in the number of pupils taking specialized science options, the insufficient level of pupils' performance in rural schools, the difficulty in changing established patterns of teaching and learning to the extent planned by curriculum developers, the question of the support for science teachers and of their deployment – are common to many other developing and developed countries. Hence the relevance of the Malaysian experience.

There is much to learn from both the successes and the difficulties that Malaysia encountered in the implementation of its policy. The issues raised, and the recommendations made should interest all policy-makers and educational planners interested in improving the coverage and the quality of science education in their country. The Institute wishes to thank the Malaysian Ministry of Education for this opportunity of co-operation, and the team directed by Sharifah Maimunah bte Syed Zin and Keith Lewin.

Jacques Hallak
Director, IIEP

Preface

In a newly emerging industrial economy like Malaysia today, the role of science and technology cannot be overemphasized. There is need for a high quality labour force which adapts quickly to a changing industrial environment, educated to maintain a high level of ethical and moral standards, and a commitment to excellence. The foundation for the education of such a workforce and of such an industrial society, as is envisaged in Vision 2020 (Wawasan 2020), must be laid now.

Developments in Malaysia in the last two decades have amply demonstrated that education and training are powerful tools towards achieving this end. In this respect, a meaningful and relevant science education would ensure the acquisition of the appropriate competence in science subjects as well as the inculcation in school children of moral and cultural standards, including those of work ethics and discipline.

In the light of the increasing importance placed on science education in school today, it is only appropriate that measures be taken to ensure the effectiveness and efficiency of its propagation. The publication of this study, which addresses issues pertaining to the planning and policy priorities in science education in secondary schools is therefore timely and relevant.

I wish to take this opportunity to thank the International Institute for Educational Planning (IIEP), Paris, for jointly funding this study and providing the necessary consultancy services. Special thanks and appreciation are extended to Keith Lewin and Françoise Caillods for their invaluable guidance and assistance.

Dato' Asia Abu Samah
Director General of Education
Ministry of Education, Malaysia

Acknowledgements

This study could not have been completed without the assistance of many people. First we must thank senior officers of the Ministry who gave freely of their time to advise, comment and reflect on science education issues. In particular, we thank the Directors of Education in the four states where the study was conducted for their helpful co-operation.

Other Divisions of the Ministry co-operated closely with us. In particular the *Examination Syndicate* assisted with the analysis of items from public examinations, the *Curriculum Development Centre* helped in the analysis of the science curriculum, and the *Mathematics and Science Unit* of the Schools Division provided useful data on schools. Other organisations were consulted. MARA was also a source of insights and staff in higher education institutions and major companies gave helpful information.

Our back-up from our secretarial support was exemplary. It was only marred by the untimely departure from this life of one of our colleagues to whose family we extend deepest sympathy.

We also owe a debt of gratitude to the many principals, teachers and students who responded co-operatively to our inquiries and made our fieldwork teams welcome. State and district officials also went out of their way to be helpful. We hope that this report does justice to their expectations.

We are grateful to both the Ministry of Education and the International Institute for Educational Planning for supporting this project and providing the financial means to undertake a study of this magnitude.

The research team was drawn from staff members of the Educational Planning and Research Division of the Ministry of Education, Malaysia. The International Institute for Educational Planning provided an external consultant.

Research team members

Sharifah Maimunah bte Syed Zin
Abdul Halim bin Ahmad
Kung Joo Jong
Mokhtar bin Sarbaini
Wan Mohd Rani bin Abdullah
Vanaja Nethiaganatarajah
Winifred Anne Lopez
Mohd Subri bin Mat Isa
Badarulzaman bin Abu Bakar
Norlaila bt Kuslan
Ahmad Basri bin Yussof
Abdul Razak la Razali

International Institute for Educational Planning

Keith M. Lewin
Françoise Caillods

Contents

Executive summary

1. The research rationale

Malaysia like many other developing countries has given a high priority to educational development. After independence Malaysia committed itself to becoming a united, progressive, economically and politically stable and forward-looking nation. Successive governments recognised that modernisation and rapid industrialisation depended on the development of science and technology. The priority attached to the development of science education is apparent in many policy documents. The Rukunegara (National Ideology) includes as one of its tenets the establishment of a progressive society oriented to science and technology. The New Economic Policy (NEP) identified science and technology as a prerequisite for economic progress and subsequent five-year plans all stress science and technology as an integral part of the national development strategy.

Most recently the emphasis on science and technology has been reiterated in the challenges outlined by the current Prime Minister in the Wawasan 2020 (Vision 2020) policy document which presents 'the challenge of establishing a scientific and progressive society that is innovative and forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future'. The challenge of full industrialization by 2020 will see:

(i) The need for a labour force with broad based education emphasizing Science, Mathematics and English Language;
(ii) An increased demand for skilled and technical manpower;

(iii) An increased awareness of science and technology as well as research and development at all levels of education.

Four main factors suggest that it is particularly timely to undertake research on science education in Malaysia. First, Malaysian national development policy has many points in common with other Newly Industrialising Countries and there may be general lessons to be learned from studying the Malaysian experience. Second, policy interventions in science education have been established long enough for their effects to become apparent and some judgements to be made about their efficacy. Third, changes recently introduced in the Malaysian national curriculum at secondary level carry implications for participation and achievement in science education and these need exploring. Fourth, the Wawasan 2020 policy initiative has a strong emphasis on science and technology development. No comprehensive research review of science education has taken place in the recent past which can contribute directly to the policy debate.

2. Some major issues

The development of science education in Malaysia has been impressive. Since 1965 all children have been free to follow secondary education to Form III which includes a core science course. Gross enrolment rates exceed 83 per cent at lower secondary and 49 per cent at upper secondary. In 1991, about 20 per cent of upper secondary students studied science as three separate subjects. Most of the remainder followed a General Science course. The number of science stream students at upper secondary level doubled between 1976 and 1986. New curricula at lower and upper secondary levels were developed and implemented during the 1970s which introduced innovations in course organisation and teaching methods. Extensive efforts were made to train more science and mathematics teachers and offer in-service upgrading to those already in the schools. Existing facilities for science have been expanded. Eighteen special science schools have been established along with 15 schools run by MARA. A Special 'Rancangan Khas' programme has been developed to provide further opportunities for rural high achieving students.

At the beginning of the research several problem areas were identified where deeper insights were needed for the development of future policy. First, the number of science stream students in upper secondary schools began to shrink in the mid 1980s. The proportion of Form IV science students fell from over 35 per cent in the early 1980s to less than 20 per cent by 1991. Second, this decline in enrolment was occurring as the number of places for science school leavers in further and higher education increased rapidly. With industrialisation the demand for science and technology qualified human resources at both professional and sub-professional levels was also increasing. Demand was growing as supply was dwindling. Third, there were concerns about the quality as well as the quantity of science-qualified school leavers. Achievement levels in some subjects suggested significant numbers of students were experiencing difficulty learning basic science. Rural schools had the lowest levels of achievement and were also beginning to have difficulty maintaining viable science classes. Fourth, developments in the curriculum and human resource needs both suggested that more science teachers might be needed. Fifth, despite the efforts to implement new curricula there were some indications that much science teaching appeared to fall short of promoting analytical and logical thinking and continued to be biased towards the recall of facts.

3. The research strategy

This study was designed with three main objectives.

(i) To describe and analyze the main characteristics of the provision of science education at secondary level;

(ii) To investigate science education provision empirically through a national survey and a series of case studies located in selected schools;

(iii) To draw conclusions related to improvements in the planning and support system for science education, to suggest new mechanisms for policy implementation.

With these objectives in mind, the study was organised in five component parts. Each component used a variety of data collection techniques.

The first component examined the condition of science education through an analysis of secondary data from existing sources. This baseline study describes and analyses patterns of provision, trends in enrolment and transition rates, the participation of urban and rural students and boys and girls, the supply of personnel and resources, and the arrangements for the organisation and delivery of the science curriculum. The main data collection methods used were documentary analysis, interrogation of Ministry statistics, and interviews with various officers at the national and state level.

The second component aimed to investigate educational and occupational opportunities for science-qualified school leavers. It involved collecting data on the flow of students through the school system and into further and higher education. From this it was possible to make judgements about the balance between supply and demand. It also analyzed existing and projected labour market opportunities for those with science qualifications. This part of the research was based on documentary evidence, data received from universities, polytechnics, and other public/private colleges and institutions of higher learning and from relevant Divisions in the Ministry of Education. In addition, interviews with key human resource personnel in both public and private sectors were also conducted.

The third component sought to deepen insights into existing patterns of science education provision through a representative survey undertaken on a selected number of schools in four states. The survey, which consisted primarily of questionnaires for school principals and science teachers, aimed at providing further information on school characteristics, enrolment in science at different levels, the educational and professional qualifications of science staff, science teachers' teaching loads, the availability and utilisation of facilities, characteristics of the system for allocating students to science, pupil performance, teaching practices, and problems in teaching science. About 7.5 per cent of all secondary schools in Malaysia were identified by the sampling process. These were located in the states of Perak, Wilayah Persekutuan, Terengganu, and Sarawak. There were 96 schools in the main sample. The response rate for the principal's questionnaire was 78 per cent and 84 per cent for the teacher's questionnaire.

A series of 13 school case-studies constituted the fourth component of the research. These added a considerable amount of qualitative data to the study and allowed insights into science education as it is actually practised which were not available from the other data. The case study schools were selected from the main sample used for the survey. Logistic considerations limited the choice to schools in the three states in Peninsula Malaysia. The case studies were conducted by teams of two researchers working in schools for approximately a week. Return visits were arranged to collect additional data and confirm insights that emerged from preliminary analysis. Interviewing, observation and several checklist inventories were used to collect data on a wide variety of issues including the general organisation of science teaching, patterns of student enrolment and achievement, the qualifications, experience and workload of science teachers, the support given to science teaching, the allocation of funds and patterns of expenditure, the utilisation of resources and facilities, aspects of the school climate and management, and perceptions of science education and problems in the teaching and learning of science.

The fifth and final component analyzed patterns of performance in examinations. This was undertaken both through analysis of public examination results at different levels and by reanalysing samples of scripts to explore in more detail differences in performance between different groups of students (e.g. rural and urban, boys and girls). This allowed the identification of parts of the curriculum and types of examination questions which caused the greatest difficulties.

4. Main findings

First the data presented here confirm the decline in the number of science stream students. This averaged 6 per cent per year between 1986 and 1990 for Form IV students, resulting in an absolute reduction in numbers of 21 per cent. Over the same period enrolments in upper secondary as a whole increased by 8 per cent. In 1991, there appears to have been a substantial acceleration of this trend. The number of Form IV science stream entrants dropped by a further 21 per cent between 1990 and 1991 as a result of tighter entrance requirements (Credit 4) for the science stream and more applications by science-qualified students to join the arts stream. The result was that in 1991 science stream students were 21 per cent of the total number of Form IV and Form V students. The number of Form IV science students in 1991 (the last year of the old curriculum) fell to the same absolute number as were enrolled in 1977.

The most recent data on option choice under the Integrate Secondary School Curriculum (KBSM) for the 1992 students based on a follow-up survey in the four states shows that, using Credit 6 as the basic requirement for taking science in Form IV, 45 per cent of the students qualified in 1992. Of these fully 48 per cent 'opted out' of science. Those taking two or three electives in science were about 20 per cent of the total

Form IV students. If the basic requirement for taking science is made more stringent, e.g. using Credit 5 or Credit 4, then the percentage who qualified would drop to 36 per cent or 31 per cent respectively. About 55 per cent of science students in Form IV were male and 75 per cent were in urban schools. National statistics from the Schools Division confirm this picture and indicate that, in 1992, 21 per cent of the total Form IV students were science biased. Twenty-five per cent of these science students were taking two pure science subjects or a combination of (COR) science and additional science (in roughly equal numbers) rather than the full complement of three separate sciences. We can conclude that the decline in science numbers as a proportion of all students stabilised in 1992 as entry criteria were brought back to the same as in 1990 (i.e. Credit 6). It is too early to say whether the mild recovery in science enrolments will be sustained.

Second the analysis of supply and demand for science school leavers reveals the magnitude of the imbalance that is emerging. In 1989, there were at most about 33,200 science-qualified school leavers at Form V and 4,400 at Upper VI available to apply for higher level courses. The calculations suggest that at least 26,400 places were available for them. Science students have more places available to them, as a ratio of the number of qualified school leavers, than do those in the arts stream. There are opportunities in science-based areas in further and higher education for about two thirds of those who study SPM science. For arts stream students the places available are closer to one third the number of school leavers at Form V level. Since all who are qualified will not take higher level courses, supply would seem barely adequate to meet demand. Moreover, the smallest numbers of science stream students were in Form IV in 1991 suggesting that the 1993 output will be even smaller though the number of places at higher levels will have increased further.

Third data on signals from the labour market support the view of emerging shortages for human resources with a science base. There are almost certainly more job vacancies available for those with science-based qualifications as a ratio of those who possess them, than for other specialisations. Indeed, by far the largest number of reported vacancies for graduates are for engineers. Data on growth in employment in the professional and technical category alone (neglecting the demand from other sectors) suggests planned growth of employment of around 27,000 a year for the next decade for technically qualified staff. This can be compared with current levels of output from Form V and Upper VI suggesting supply is likely to run behind demand. Under the OPP2, general economic growth is projected at about 7 per cent for the rest of the decade. This level of increase in science enrolments would seem a minimum target to aim for to meet projected demand. It may also be relevant to consider changing the balance in higher level courses in favour of the applied sciences where demand is strongest but growth has been slower than for pure science courses, especially at degree level.

Fourth the analysis of examination performance data confirms that in some areas overall levels of achievement leave room for improvement. Whilst a core of successful schools consistently achieve good results in all subjects, and students in special science schools with selective intakes consistently outperform others, the position in many rural schools and those with small enrolments is less satisfactory. Data on performance in Integrated Science shows that only about 13 per cent of rural schools had a proportion of distinctions above the national mean proportion of 8 per cent. On the other hand, 63 per cent of urban schools scored above this level. In 80 per cent of the rural schools in the sample more than 50 per cent of students only achieved pass grades (P7 and P8). In General Science, 36 per cent of rural schools and 70 per cent of urban schools have pass rates above the national mean, and no rural school scored above the national average proportion of distinctions (4 per cent). In about 75 per cent of these rural schools, 75 per cent of candidates failed the subject or achieved pass grades only (P7 and P8). There are similar though smaller differences in pure science subjects with about 30 per cent of rural schools and 70 per cent of urban schools scoring above the national average pass rate (84 per cent). If the supply of science-qualified school leavers is to be increased it may be most equitable and efficient to direct attention to reductions in disparities in performance between schools.

Item analysis provides indications of where difficulties are concentrated for different groups of students. In general, physics-related topics tend to be more difficult for most students. Girls especially appear to perform poorly on questions concerned with electricity. Though rural students generally perform at lower levels on some types of item their performance can be comparable to their urban counterparts suggesting that part of the problem may lie in how questions are presented as well as in how adequately topics are taught. The research demonstrates that powerful insights into areas of difficulty can be generated by item analysis techniques which might provide the basis for intervention to support more effective teaching and learning. The development of KBSM provides opportunities to act on this information.

Fifth a majority of the schools in the sample had one or no science stream in 1991. Though class sizes in high achieving urban schools were often large, those in rural schools and those with small enrolments often have science class sizes of less than 20 which are at the margin of viability. It is in these schools that the decline in enrolments has been greatest. The data collected describe how the conditions for teaching science in these schools may combine together to discourage improvements in participation and achievement. A new look at science provision in these schools (which include low performing urban schools) is desirable starting from the analysis offered in this study.

Sixth the research data identifies a prospective problem in science teacher deployment. About 70 per cent of those teaching science are trained as science teachers, and about 17 per cent of trained science teachers are teaching other subjects. Inter and intra school deployment patterns result in the under-loading of some science teachers in terms of science teaching periods and the teaching of science by non-science trained teachers. With a wider range of option choices under KBSM time-tabling will become more complex. The research suggests there are needs to improve the efficiency with which teachers are allocated to schools and to science teaching to ensure that utilization rates of science-trained teachers are high and that almost all students are taught science by those trained to teach the subjects. It may also be important to upgrade the qualification profile of lower secondary teachers since this is where non-graduates are concentrated and to work to improve the quality and motivation of general science teachers who are those least satisfied with being allocated to teaching the subject.

Seventh the projections of the number of science teachers needed presented in the study confirm that demand will increase over current levels. Expansion of the enrolled cohort in Form IV and V will take place and this will increase demand for science teaching whatever option choices are made. Upgrading certificate teachers (currently over 40 per cent of all those teaching science) to degree status to create an all-graduate profession will increase demand for training. Science teachers are also being called on to teach new options until those with specialist training become available, e.g. living skills, technical and some vocational options. Annual demand for new science teachers seems likely to fall between 1,000 and 1,500 per year compared to current output which appears to be in the range of 400 to 600 depending on the assumptions made. The numbers will be significantly larger if non-graduates are replaced by graduates and could exceed 2,000 per year.

The research suggests that a number of curriculum problems remain unsolved. Implementation of new science curricula has not yet succeeded in changing established patterns of teaching and learning to the full extent planned by curriculum developers. Developing intellectual problem-solving strategies is under valued in much of the teaching observed, examination orientation strongly influences the learning experience of students in ways which stress the recall of information, practical work often occurs in large groups with limited student participation in design and interpretation of results and students' work is not generally characterised by opportunities for original expression. Since there are schools where all these things are achieved in some measure the curriculum implementation problem is how to encourage more widespread adoption of recommended learning and teaching strategies and the present research sheds light on steps that might be taken.

The introduction of KBSM extends the curriculum challenge. Students taking two rather than three science subjects are becoming more common. Principles of accounts is becoming a popular choice amongst science students and combinations which include this, or other popular options with science may be a way of encouraging more students to specialise in science. Most schools are not large enough to offer all options and elective subjects. Balance should remain an underlying principle in permissible students choices and there is a need to advise schools on patterns of option choice that respond to student inclinations, provide coherent and balanced science education, and reflect national needs to increase the number of science-qualified school leavers.

5. Main policy issues and recommendations

The recommendations made fall into five inter-related categories. These are summarised below.

5.1 Student flows through science education

(i) The decline in the numbers of students taking specialist science options should be reversed. This is a priority if the human resource development needs of Wawasan 2020 are to be met;
(ii) Special attention should continue to be given to create more opportunities for rural students to study science. Science enrolments in rural schools are declining faster than elsewhere notwithstanding the existence of the successful special programmes for selected groups of students;
(iii) Variations in opportunities to study science between states should be gradually reduced to make full use of the nation's human resources;
(iv) Patterns of option choice under KBSM in science subjects should be kept under close review to ensure an adequate supply of science specialists into further education and training and balance in the science curriculum;
(v) The rate of expansion of opportunities for science education in further and higher education should be matched to levels that can be sustained by school output without reductions in quality;
(vi) Information on opportunities in further and higher education and in the labour market should be made more widely available at school level.

Strategies to improve participation in science and technology-based education in general cannot depend, except at the margin, on substantial expansion of the existing provision in special institutions if only because the cost burden would be severe. Over 95 per cent of the school population will continue to experience science through schools resourced at or near normal government levels. Thus, the majority of those who follow professional careers in science, and the overwhelming numbers of those entering middle level careers based on science and technology, will remain graduates from normal secondary schools.

It will be, however, necessary to find more ways of disseminating good practice in science education to other schools including possible twinning arrangements of some science schools with others in the locality; identify core schools for additional support for science; offer incentives for disadvantaged urban students and girls to continue to study science at higher levels; provide additional resources to those states where provision is weakest to bring participation and achievement closer to national levels.

5.2. *The organisation, management and support for science education*

(i) Responsibilities at school level for the development of science teaching and the improvement in achievement levels of students should be clearly defined and located with particular members of staff;
(ii) Inspection, supervision and support systems for the development of science education should be strengthened;
(iii) The resource allocation system for science in rural schools with small science stream enrolments requires special attention;

Though science and technology are prominent priority areas in national development plans science is not accorded special priority by most school administrations. Very few school principals have special competencies in science. Senior science teachers rarely receive training and their responsibilities do not appear to be clearly defined. Under the proposals for the reorganisation of schools senior posts are to be created that include one with special responsibility for science and mathematics. A first step would be to initiate in-service training and staff development courses alongside small-scale research into the role of senior science teachers.

The frequency of supervision, deployment of state science curriculum officers, and sources of professional advice for science teachers are limited in their effectiveness by their scarcity. Much could be done in this area which could have considerable benefits at relatively low cost.

The special conditions of rural and small schools invite systematic as opposed to ad hoc arrangements. The standard resource allocation pattern makes little allowance for varying conditions. Capitation arrangements should recognise this by allocating a greater amount per student to schools with designated characteristics.

5.3 *Monitoring student achievement in science*

(i) More sensitive school performance indicators need to be developed that provide widely understood and readily available information to monitor performance and identify schools which are underperforming;

(ii) Diagnostic item analysis should be undertaken at national level on samples created to examine the performance differences between different groups of students;

(iii) More detailed feedback of performance on science examinations should be provided to schools;

(iv) Support is needed for the development of more effective performance monitoring within schools.

5.4. Curriculum issues

(i) The Curriculum Development Centre should be invited to follow up the specific areas of learning and teaching difficulties identified in this study in science and related mathematics curricula and develop appropriate enrichment material;

(ii) More science reference material should be developed in Bahasa Melayu;

(iii) The role of practical work should be reconsidered in view of current patterns of use and costs;

(iv) The General Science curriculum should be reviewed to improve its relevance and the levels of achievement of students who study the subject.

Further curriculum development of the various science courses is desirable. There is however no evidence that the basic form of the curricula are unsatisfactory. Rather there are indications of a number of areas in which enrichment, review, revision, and changes on the margin could pay dividends. The problems seem to lie predominantly in the implementation and management of effective teaching and learning and with enrichment to help overcome specific areas of difficulty. The research shows that practical work is most commonly conducted in groups of five or six. Much practical activity is designed in ways which seem to imply group sizes of two or three if all students are to be involved. Similarly, the pattern of use of textbooks and work books identified in the case studies gives food for thought about officially provided materials. The question is to what extent should the curriculum be changed to reflect preferred patterns of use (in the examples above large practical groups and heavy use of workbooks). Or, alternatively, what additional conditions would need to exist if intended patterns of use were to become more widespread?

In most schools there was very limited evidence that practical work was used to develop and reinforce intellectual skills despite its high costs. This suggests either that the curriculum rationale for practical work be reconsidered and the demands made by it on resources be reduced, or that new efforts are needed to ensure that practical work is used for its intended purposes to provide both concrete learning experiences and opportunities for scientific thinking. A pilot project should be considered to develop techniques for the more effective use of practical work to teach intellectual skills based in schools where this is not common practice.

The one subject that may be an exception to the general view that curriculum development might best be directed towards enrichment rather than redesign is General Science in upper secondary schools. The research suggests that achievement in this subject is often poor, teaching is frequently classroom based with no practical work, and many general science teachers are not strongly committed to the subject. It is however the most frequently taken science subject (by over 75 per cent of students) and the last experience most students have of science.

5.5 *The deployment and training of teachers*

(i) Teacher deployment at the inter and intra school level requires reexamination to ensure that trained science teachers are used efficiently and that as much science as possible is taught by trained science teachers.

(ii) The projections of science teacher supply and demand made in this situation should be refined and undertaken annually.

(iii) Selective expansion of science teacher training is required to ensure that a balance is maintained in the supply and demand for science teachers.

(iii) Science teachers at lower secondary level, and particularly those teaching the lower forms and those teaching General Science, should have their professional qualifications upgraded.

(iv) An appropriate balance needs to be struck in initial and in-service training between innovatory methods for science teaching and those which have demonstrated their effectiveness over time.

The development of Educational Management and Information Systems (EMIS) provides an opportunity to include data on school staffing which can be easily accessed at the time when deployments are being considered. To achieve this a clear view has to be taken on the definition of those qualified to teach science.

Since the implementation of the different science curriculum has been identified as a more central problem than the curriculum itself it is clear that effective initial and in-service training is critical. On the limited evidence available, it is suggested to favour closer relationships between initial training institutions and schools, with more encouragement for the involvement of experienced and effective science teachers based in schools in the training process.

Research evidence on the effectiveness of in-service training is paradoxical. This is an area for further research before embarking on any general expansion of what are already commendably high levels of in-service effort.

5.6 Reflections

First, though the study has focused on secondary science this should not be taken to reflect complacency about other levels. Science education is a continuous experience that starts in a relatively unstructured way when young children first begin to explore the world they have entered through their senses. Much can and should be done in primary schools to help to develop conceptual frameworks through which to interpret experiences of the natural world. This is both because the foundation built at this level is the bedrock on which more systematic knowledge and understanding of science may be built at later stages, and because learning about science is itself a method through which cognitive development can be encouraged.

Second, permeating the explanation of the swing away from science, we identified, is the inference that increasing numbers of students have a negative attitude to the study of science and that this probably strengthens the older the students are. Though there is no hard evidence on this it seems that the climate of opinion that influences the choices students make and the motivation they bring with them to study science has changed over the last two decades. There may be many reasons for this. The Malaysian recession in the late 1980s brought the vision of unemployed science graduates to the notice of the public for the first time. The perception of science *as a difficult subject* may have become more entrenched as greater proportions of the age group began to study science. Economic diversification and growth have created a much broader range of job opportunities than existed a decade ago some of which are more remunerative than jobs requiring qualifications in science and technology.

All of these possible explanations can be contradicted. Currently labour market demand for those with science and technology qualifications appears buoyant and set to continue to grow especially for those with applied science backgrounds at all levels. Science is not in fact more difficult than other subjects if judged by the distribution of examination grades – English and Mathematics tend to be more difficult. Though there is a great deal of interest in courses of study that lead to highly paid occupations (e.g. accountancy) that are not science based, most of these professions do not preclude science students from entering them and some actively encourage applications from science students. Engineers are in demand and are highly paid.

The point here is that the quantitative and qualitative problems identified in planning future provision in science cannot be solved without generally held positive attitudes to the subject and to the value of studying it. This is a challenge to science educators, and to Malaysians who wish to 'make science and technology integral components of socio-economic planning and development and promote a science and technology culture compatible with the process of building a modern industrial economy'. It is clear that simply creating more opportunities to study science will not succeed in overcoming the problems. Without attention to improving motivation and quality the consequence would be a reduction in standards as greater numbers participated. Thus improved access should be accompanied by initiatives on a broader front which seek to encourage demand for places studying science, improve awareness of the opportunities that this creates, and maintain and improve standards of entry and achievement.

Finally, at the heart of a number of the planning issues identified is a dilemma. The choice is between using planning to monitor the effects of demand generated by individual decisions, and using planning to determine the pattern of educational opportunity that is available to serve national needs for human resource development. These two extremes can be conveniently described as responsive and indicative planning. In some respects planning for science education in Malaysia seems to have moved away from indicative planning (where science stream numbers were controlled and students were allocated centrally to the places available) to a more responsive planning approach where student choice is given greater weight. This seems less true in other areas (e.g. finance, curriculum) where central control has been maintained.

An acceptable compromise needs to be found between the legitimate aspirations of individuals and the responsibilities of government to take a view of the collective interest. Allowing the 'market' full autonomy may have some attractions if the conditions of free markets can be approximated (e.g. unconstrained choice, equal access to information). These conditions are difficult to meet. Most students cannot, in practice, choose the school they attend, schools are themselves limited in the options they can provide, information is unevenly available, and other factors (e.g. family circumstances) may determine choice for some and not for others. Even if conditions are acceptably close to a free market there will be time lags that can have some quite serious consequences. Educational investment cycles (e.g. in building science teaching facilities) are medium-term projects. Market signals can be quite unstable swinging from surplus to deficit rapidly.

Thus a strategic issue is to decide to what extent the 'market' in science education can and should be managed and what policy instruments can be used for this purpose. It seems likely that such an approach is needed, at least on the enrolment side of science education planning, if sufficient flows of suitable quality school leavers are to be maintained. Expansion in science- and technology-based further and higher education will otherwise be constrained by a shortage of suitably qualified applicants, and the human resource development needs may become difficult to meet. Without selective intervention it may also be the case that the special needs of groups who are educationally underprivileged in science education (e.g. rural students) will suffer relative neglect and differences between the groups will grow.

Chapter 1

Planning science education in Malaysia: a programme of research

1. The research rationale

Malaysia, like many other developing countries, has given a high priority to educational development and has invested extensively in science education over three decades. After independence it committed itself to becoming a united, progressive, economically and politically stable and forward-looking nation. Successive governments recognized that modernisation and rapid industrialisation depended on the development of science and technology. The priority attached to the development of science education is apparent in many policy documents. The Rukunegara (National Ideology) includes as one of its tenets the establishment of a progressive society oriented to science and technology. The New Economic Policy (NEP) promulgated in 1971 identified science and technology as a prerequisite for economic progress and explicitly developed educational strategies to encourage its development. Subsequent national five-year plans all stress science and technology as an integral part of the national development strategy.

Most recently the emphasis on science and technology has been reiterated in the challenges outlined by the current Prime Minister in the Wawasan 2020 (Vision 2020) policy document which sets the development agenda to the year 2020. His speech to the Malaysian Business Council on 28 February, 1991, outlines 'the challenge of establishing a scientific and progressive society that is innovative and forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future'. The challenge of full industrialisation by 2020 will see:

(i) The need for a labour force with broad based education. emphasizing Science, Mathematics and English Language.
(ii) An increased demand for skilled and technical manpower.
(iii) An increased awareness of science and technology as well as research and development at all levels of education.

The Sixth Malaysia Plan (1991-95) argues that the foundation for the establishment of a scientifically and technologically advanced industrial society must be consolidated now by nurturing a scientific and progressive society which depends on widespread access to science education of appropriate quality.

Partly as a result of this strong commitment to science and technology Malaysia has been able to sustain high rates of economic growth over a long period and has established itself firmly as a Newly Industrialising Country (NIC) where sustained development has taken place. Traditional economic activities have been displaced by rapidly growing manufacturing and service industries which are competitive in export markets and which generate high value-added; agricultural production has been modernised and effective use has been made of new technologies of production and processing; plans for the future assume growing demands for science-trained employees to meet the needs of an increasingly sophisticated labour market. Malaysia is now the largest exporter of microchips and the third largest producer in the world, to take one example of how important technologically based industries are becoming. Science education in Malaysia has benefited from systematic government support resulting in the establishment of many new educational institutions, a variety of special programmes to improve participation in science education, and investment in curriculum development at all levels.

Four main factors suggest that it is particularly timely to take stock of achievements to date, appraise current issues and emerging problems, and identify the most promising avenues for further developments in the planning of science education. First, Malaysian national development policy has many points in common with other Newly Industrialising Countries, especially those around the Pacific rim. There may therefore be general lessons to be drawn of interest to other countries in the region from studying the Malaysian experience in investing in science education, an area widely regarded as strategically critical and also one where costs tend to be high. Second, policy interventions in science education have been in place long enough for their effects to become apparent and some judgements to be made about their efficacy. Where future needs mimic those of the past, successful initiatives need to be identified and extended. Where new demands are arising as development takes place new interventions need to be devised, based on insights from research, past experience and creative consideration of the range of possibilities. Third, changes recently introduced in the Malaysian national curriculum at secondary level carry implications for participation and achievement in science education. These developments require careful matching with national needs if the greatest benefits are to be achieved. Fourth, during the course of this research the Wawasan 2020 policy initiative was announced with a strong emphasis on science and technology development. Since no other comprehensive research reviews of science education have taken place recently, this work is especially timely and should contribute directly to the policy debate.

1.1 Some major issues

The development of science education in Malaysia has been impressive. Since 1965 all children have been free to follow secondary education to Form III (grade 9) which includes a core science course. Gross enrolment rates exceed 83 per cent at lower secondary and 49 per cent at upper secondary. In 1991, about 20 per cent of upper secondary students studied science as three separate subjects. The remainder followed a General Science course. With the expected extension of basic education from 9 to 11 years to the end of upper secondary, an unprecedented number of Malaysian children will study some science up to the point where they enter the labour market.

New curricula at lower and upper secondary levels were developed and implemented during the 1970s to replace those inherited from the pre-independence period. These introduced innovations in course organisation and teaching methods. Extensive efforts were made to train more science and mathematics teachers and offer in-service upgrading to those already in the schools. Equipment grants accompanied the introduction of the new courses and laboratories were provided to virtually all secondary schools. New science curricula stressed approaches to teaching and learning which emphasised guided discovery, more child-centred learning and advocated the use of much more practical activity. They were intended to shift the emphasis away from rote teaching of factual information towards the development of problem-solving skills, reasoning powers and achievement at higher cognitive levels.

By 1990 access to science education had expanded to cover almost all of the secondary school population. This was mainly achieved through the expansion of existing facilities for science. In addition to the new schools built to accommodate increased enrolments at secondary level, eighteen special science schools were established, located in all but one of the states. MARA, an organisation established to promote rural development, also developed its own system of 15 schools specialising in science. The Rancangan Khas programme was developed to provide further opportunities within the normal secondary school system for rural high achieving students not admitted to the various residential schools.

Taken together the various initiatives resulted in considerable achievements. During the latter part of the 1980's the supply of science-qualified students was in balance with demand and in some cases appeared to exceed the numbers needed. The number of science stream students at upper secondary level doubled between 1976 and 1986. Improvements in access to science education for rural students allowed their participation rates to increase over this period. Quality improvement programmes began to change the teaching and learning of science.

Alongside these successes some difficulties remained and new ones began to emerge in the early 1990s. The most important of these are outlined below and form major areas of interest for this research.

First, the number of science stream students in upper secondary schools began to shrink in the mid 1980s at a time when total enrolments in upper secondary were increasing. As a result the number of upper secondary science students at the beginning of the 1990s was comparable to that in the mid 1970s and the proportion of science students fell from over 35 per cent in the early 1980s to less than 20 per cent in the 1990s. In 1967, the Higher Education Planning Committee had suggested that 60 per cent of students should be in science in schools and higher education. Concerns have also been raised about the growing proportion of students who qualify for science but chose to opt for the arts stream at upper secondary and sixth form level. More data is needed to trace the patterns of this swing away from science and establish whether it is likely to continue.

Second, the number of places for science school leavers in further and higher education increased rapidly during the 1980s. Further substantial expansion is planned in higher level places requiring science entry qualifications under the Sixth Malaysia Plan and the Second Outline Perspective Plan 1991-2000 (OPP2). This suggests that there will come a point where the supply of qualified applicants may outstrip the demand. Since not all qualified science school leavers will continue with science, and alternative opportunities have been growing as the labour market has expanded, the shortfall may appear sooner rather than later. Though some of the shortfall may be made up from entrants who have studied General Science at upper secondary level these students have a much weaker grounding in basic science than science stream students. Projections are needed to identify how soon problems may arise.

Third, under the OPP2 total employment is planned to grow at 3.1 per cent per annum. With industrialisation, the demand for science and technology-qualified human resources at both professional and sub-professional levels is likely to grow at a greater rate. General economic growth is projected at about 7 per cent for the rest of the decade and the growth in demand for science- qualified personnel is likely to be comparable to this. Though signals from the labour market in the late 1980s of the strength of demand for science school leavers seemed ambiguous the situation seems to be changing rapidly. Research is needed to establish the current position.

Fourth, there is a continuing concern about the achievement of science school leavers. At lower secondary level the largest numbers of candidates achieve pass level performance; invariably it is a smaller number who obtain credits or distinctions and about 20 per cent fail. Science stream students performance at upper secondary is generally more satisfactory with about 50 per cent achieving credits or distinctions and 15 per cent failing. In General Science, the option followed by more than 75 per cent of upper secondary students, overall pass rates average about 65 per cent and less than 30 per cent obtain credits or distinctions. More analysis of examination performance data is required to uncover differences in performance between schools and different groups of students, and to identify special areas of weakness which might suggest how performance can be improved.

Fifth, the decline in science stream enrolments may have a number of consequences. Falling enrolments in science are unlikely to occur evenly. They may be concentrated in rural schools and those with small total enrolments. In some schools there will come a point where enrolments are too small to maintain viable science stream classes. Changes introduced under the new curriculum in 1992 will allow more student choice of subject option. This may worsen the situation, especially in relation to the physical sciences which are generally regarded by teachers and students as more difficult. Research should show whether these suppositions are justified.

Sixth, overall the supply and demand for science teachers is broadly in balance. However, it may be that patterns of deployment result in the under-loading of some science teachers and the teaching of science by non-science trained teachers. There may also be a tendency to concentrate the best science teachers in a small number of schools whilst others suffer shortages. In addition, General Science, the option taken by most upper secondary students until 1991, may be taught by the least qualified teachers. All these possibilities have important consequences for the development of science education and an analysis is needed to establish the extent to which they occur.

Seventh, the demand for trained science teachers is likely to increase considerably over current levels. Several factors are responsible for this. It is expected that the extension of basic education from 9 to 11 years will result in an increase of over 60 per cent in secondary school enrolments by the year 2000. The move to an all graduate teaching profession necessitates the upgrading or replacement of non- graduate teachers who currently constitute about half of all science teachers. If the swing away from science in enrolments is reversed this will increase the demand for science teachers. Even if it is not, the demand for teachers with a background in science is likely to be increased by their deployment to teach new curriculum subjects – e.g. living skills, and technical and some vocational options, until sufficient teachers for these new options are trained. Annual demand for new science teachers therefore seems likely to grow and training of graduate science teachers is now at a low level. Estimates are therefore needed of how many new science teachers will be needed to meet future demand so that appropriate training courses can be organised in good time.

Finally, what evidence there is indicates that much science teaching is still focused on the acquisition of factual knowledge, and that though practical work is widely undertaken its purposes are often unclear and the intellectual strategies that practical work can help foster are insufficiently stressed. Much science teaching appears to fall short of promoting analytical and logical thinking, and other higher level cognitive skills. The limited range of learning outcomes assessed by examination questions appears to influence much teaching and learning to the exclusion of objectives for science education that are not directly assessed. The extent to which this is true is therefore another focus of concern.

1.2 The research strategy

This study has three main objectives which derive from the concerns outlined above.

(i) To describe and analyze the main characteristics of the provision of science education at secondary level. This will provide a comprehensive overview of the recent development of the science education system, describe curriculum patterns, identify trends in enrolments and participation at different levels, and explore opportunities for science-qualified school leavers in further education and employment in the context of national development plans.

(ii) To investigate science education provision empirically through a national survey and a series of case studies located in selected schools. This will allow a detailed portrayal of science education in practice to be developed. From this it should be possible to gain a much deeper understanding of current issues and problems at the operational level, chart the effects of recent changes in science education policy, and identify areas in which interventions might have most impact on participation and improved quality in science education. Part of this enquiry will focus on patterns of achievement and analysis of performance data with a view to locating particular problem areas and identifying the characteristics of low performing groups.

(iii) To draw conclusions related to improvements in the planning and support system for science education, to suggest new mechanisms for policy implementation, and to indicate areas which need to be considered in policy dialogues within the Ministry.

With these objectives in mind, the study was organised in five component parts which could provide different perspectives on the planning and development of science education. Each component used a variety of data collection techniques. More detailed discussion of the research methods, the sampling used, and the data collection instruments is provided in the *Appendix I*.

The first component of the research examined the condition of science education through analysis of secondary data from existing sources. This baseline study started by considering recent policies on science and science education in the context of national development plans. It then explored the current status of science education in schools, the supply of personnel and resources, the flows of students through secondary education, trends in terms of enrolment and transition rates, the participation of urban and rural students and boys and girls, and the organisation and delivery of the science curriculum. The performance of students in national science examinations was also examined briefly. The baseline study thus provides a systematic inventory of the status of science education and assists in identifying key areas for closer study in other aspects of the research. The main data collection methods used were documentary analysis, interrogation of Ministry statistics, and interviews with various officers at the national and state level.

The second component aimed to investigate educational and occupational opportunities for science-qualified school leavers. It involved collecting data on the flow of students through the school system and into further and higher education. It also analyzed existing and projected labour market opportunities for those with science qualifications. From this it was possible to make judgements about the balance between supply and demand. This part of the research was based on documentary evidence, data received from universities, polytechnics and other public/private colleges and institutions of higher learning and from relevant Divisions in the Ministry of Education. In addition, interviews with key human resource personnel in both public and private sectors were also conducted.

The third component sought to deepen insights into existing patterns of science education provision through a representative survey undertaken on a selected number of schools in four states. The survey, which consisted primarily of questionnaires for school principals and science teachers, aimed to provide information on school characteristics, enrolment in science at different levels, educational and professional qualifications of science staff, science teachers' teaching loads, availability and utilisation of facilities, characteristics of the system for allocating students to science, pupil performance, teaching practices, problems in teaching science including the identification of difficult topics in the curriculum, and some aspects of attitudes towards the study of science. Ninety-six schools located in the states of Perak, Wilayah Persekutuan, Terengganu, and Sarawak were identified, i.e. about 7.5 per cent of all secondary schools in Malaysia. The response rate for the principal's questionnaire was 78 per cent and for the teacher's questionnaire 84 per cent.

A series of 13 school case-studies constituted the fourth component of the research. These added a considerable amount of qualitative data to the study and allowed insights into science education, as it is actually practised, which were not available from the other data collection methods. The case study schools were selected from the main sample used for the survey. Logistic considerations limited the choice to schools in the three states in Peninsular Malaysia. The case studies were conducted by teams of two researchers working in each school for approximately a week. Return visits were arranged to collect additional data and confirm insights that emerged from preliminary analysis. Interviewing, observation and several checklist inventories were used to collect data on a wide variety of issues including the general organisation of science teaching, patterns of student enrolment and achievement, the qualifications, experience and workload of science teachers, the support given to science teaching, the allocation of funds and patterns of expenditure, the utilisation of resources and facilities, aspects of the school climate and management, and perceptions of science education and problems in the teaching and learning of science.

The fifth and final component analysed patterns of performance in examinations. This was undertaken both through analysis of public examination results at different levels and by reanalysing samples of scripts to explore in more detail differences in performance between different groups of students (e.g. rural and urban, boys and girls). This allowed the identification of parts of the curriculum and types of examination questions which caused the greatest difficulties.

Research reports were produced on each of the five dimensions in the course of the research. These are entitled the Baseline Study on Secondary School Science Education in Malaysia; Flows of Students from the School System; The School Case Study Report - Synthesis; The Report on the Survey of Schools, Principals, Teachers and Students; and The Analysis of Performance on SRP and SPM Science Examinations. They are available as internal documents of the Ministry of Education, Malaysia. This book synthesises information and analysis from all parts of the research.

1.3 The major research questions

Research questions were identified for each aspect of the research. In summary the questions fell into three main groups.

(i) *The organization of science education*

The main research questions in this area included:

- What are the national policy priorities which shape the aims of science education and how are these interpreted by those responsible for designing and implementing the curriculum?
- What is the flow of students through the science education system and how has it been changing in recent years? How has the proportion of students studying science in different streams and in different types of school varied?
- How is the curriculum organised; what patterns of teaching and learning are anticipated; how much teaching time is allocated to science in different streams and at different levels?

(ii) *Science education in practice*

- What are the main characteristics of the schools that affect teaching and learning in science? Which teachers are teaching how much science? What proportions of students have been following different curricula and how are they being allocated to these? How has science provision been changing in the recent past?

- What resources are available to support science teaching and how are they utilised for different groups of students? What learning materials do students have access to? What is the availability of laboratory space? How effectively is laboratory time used? Are there shortages of equipment? Is sufficient money available for consumable items?
- What evidence is there that science curricula are being implemented in the manner intended? Which areas of the science curriculum create the most difficulties? What do teachers identify as the most important problems in improving performance and increasing participation in science?
- What can be learned from the variation in practice between case study schools? What special problems are associated with science education in rural schools and low performing urban schools?

(iii) *The assessment of performance*

- How are examination performance and other criteria used to allocate students into different forms of science education? How have selection practices changed recently and what are the implications for the flows of students through science education?
- What are the patterns of overall achievement of different types of students in different schools at different levels? How do these vary between urban and rural schools, girls and boys, and high and low achieving students? What do they indicate about how much science is learned by which students?
- What can we learn from the analysis of performance on examination questions about what differentiates high and low scoring, urban and rural as well as male and female students? Which topics are difficult in general and for particular groups of students?

These questions were explored in one or more of the five components and wherever possible corroboration was sought for key insights from more than one source of data.

1.4 The structure of the report

The report is organised in three parts.

Part I is concerned with presentation of data from the Baseline Study and from the research on the destination of science-qualified school leavers. *Chapter 2* gives an overall picture of the current status of science education. It begins with an outline of the national education system. This is followed by an analysis of enrolment patterns at different levels and data on the selection of students into science and the public examinations used. Basic information on the organisation of the old and new science curricula is provided. The chapter concludes with a discussion of the characteristics of science teachers and the support system for science education.

Chapter 3 first examines the flows of students through the science education system and into further and higher education. It develops estimates of the balance between supply and demand. Subsequently it explores the pattern of demand for science-qualified school leavers in the labour market, analyzes the implications of projections made in the plan, and offers some suggestive evidence on levels of satisfaction with science-qualified school leavers.

Part II of the study reports on the empirical data. *Chapter 4* introduces the survey data and the case study schools. It reports on characteristics of schools and science teachers, and explores changes in enrolment patterns and other basic features of the schools in the survey sample. It then summarises the features of the 13 case study schools, provides background information and presents data on science enrolments, the organisation of teaching, and other general attributes of the schools.

The next four chapters extend the analysis of science education in practice using information from all parts of the empirical work. *Chapter 5* discusses the reasons for the decline in science enrolments and presents examples of recent developments in case study schools. It then describes and analyses how science is taught and problems that arise. *Chapter 6* focuses on characteristics of science teachers in more detail. It also presents the projected demand for science teachers and provides a range of scenarios for increases in teacher training based on different assumptions. *Chapter 7* presents data on the professional support science teachers receive and opinions on its effectiveness. It also analyses the availability of physical facilities and equipment and identifies shortcomings. *Chapter 8* completes the presentation of data and develops an analysis of examination performance data. This is undertaken first on national results and secondly through remarking selected scripts from the 1990 science papers. The latter enables patterns of performance between groups to be displayed and gives indications of science topics where learning is most problematic.

Part III concludes the study. *Chapter 9* reviews the main findings and offers a series of policy-related conclusions and suggestions for developments in planning systems.

Part I

A baseline study

Chapter 2

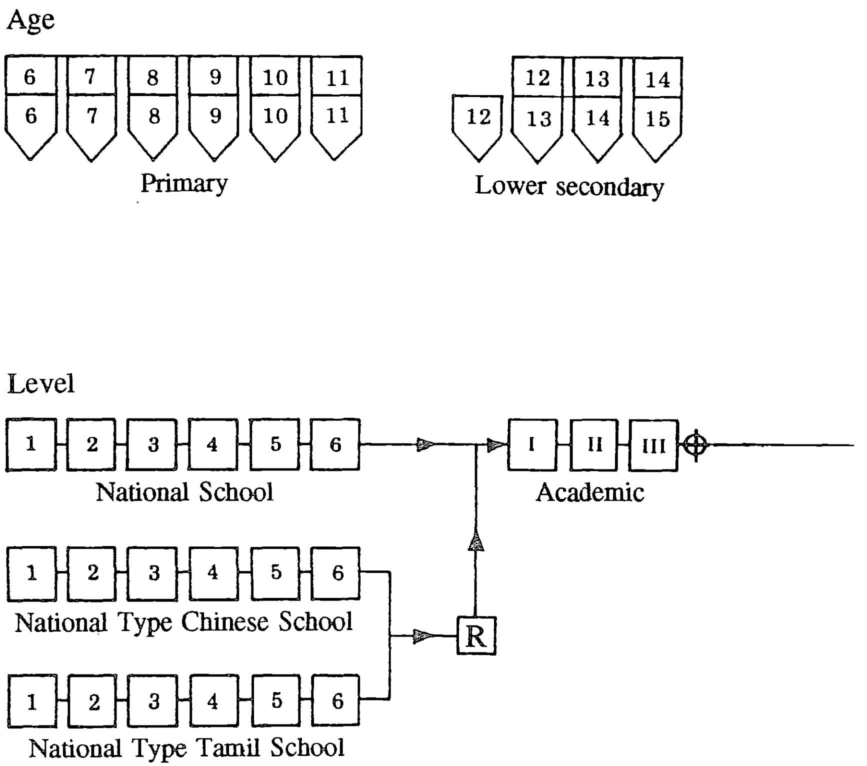
Science education in Malaysian schools: an overview

This chapter considers recent developments in secondary science education in Malaysia and provides an overview of patterns of provision. It includes an introduction to the education system and a descriptive analysis of enrolment patterns, selection mechanisms, aims and objectives for science education, the organisation of teaching and learning at different levels, performance in examinations, the provision of science teachers, and arrangements for support and supervision.

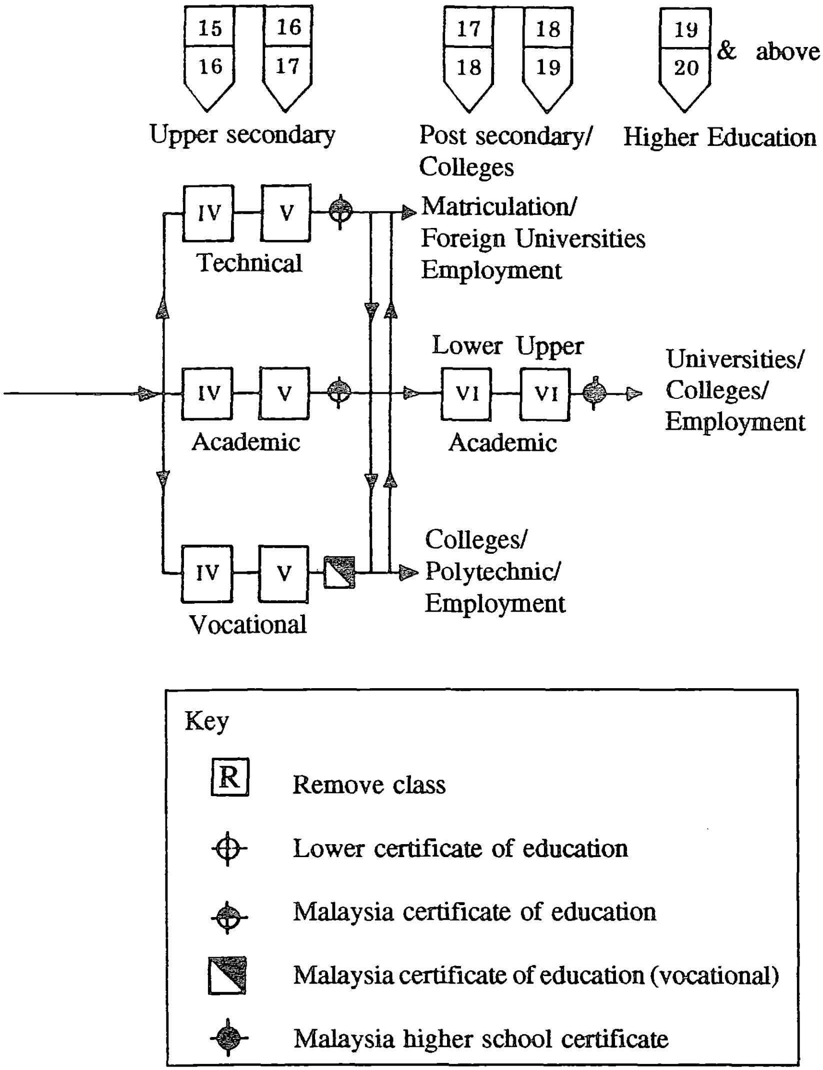
2.1 Overview of the Malaysian education system

Malaysia is divided into 13 states and Wilayah Persekutan (the Federal Territory), but the curriculum is the same all over the country. Educational administration is undertaken from the Ministry of Education through State and District Education Offices. There are 6859 primary schools in Malaysia and 1359 secondary schools. Enrolment of students by state at different levels is shown below indicating that the majority of students are enrolled in Peninsular Malaysia and are concentrated in the more urbanised states. Broadly speaking Malaysia can be divided into relatively developed states on the West coast (Penang, Perak, Selangor, Wilayah Persekutan, Negeri Sembilan, Johore), less densely populated and less developed rural states (Kelantan, Terengannu, Kedah, Perlis, Pahang), and the East Malaysian states of Sabah and Sarawak. The latter are large and less developed with relatively poorer infrastructure and low population densities. Historically educational development has occurred more rapidly in the West coast states. The educational systems of Sabah and Sarawak were the last to be integrated into the Federal system. (*See Map 1 in Appendix II*).

Chart 2.1 The education system in Malaysia (up to 1991)



Source: Educational planning and research division, Ministry of Education, Malaysia.


15
16
16
17
17
18
18
19
19
20
& above
Upper secondary
Post secondary/
Colleges
Higher Education
IV
V
Technical
Matriculation/
Foreign Universities
Employment
Lower Upper
IV
V
Academic
VI
VI
Academic
Universities/
Colleges/
Employment
IV
V
Vocational
Colleges/
Polytechnic/
Employment
Key
R
Remove class
Lower certificate of education
Malaysia certificate of education
Malaysia certificate of education (vocational)
Malaysia higher school certificate

The formal school system in Malaysia has a 6-3-2-2 pattern. This characterises the length in years of the primary, lower secondary, upper secondary and Form VI levels respectively. *Chart 2.1* represent the structure of the formal school system before 1991. Under the new Kurikulum Bersepadu Sekolah Menengah (KBSM) the upper secondary level will consist of only two streams, vocational and academic. Technical schools will not continue as a separate category.

Table 2.1 shows population, enrolment and enrolment ratios at various levels for 1990. Gross enrolment ratios for primary education exceeded 90 per cent during the 1980s and approached 100 per cent by 1990. For the same period, transition rates from primary to secondary education fluctuated between 85 per cent and 90 per cent. At secondary level, gross enrolment ratios for Forms I to III averaged a little over 80 per cent and approached 50 per cent for Forms IV and V. Repetition and over age enrolment do occur but not in substantial quantities. In 1990, a total of 94,272, students were enrolled in post-secondary, government-run institutions. Another 54,707 were in the 7 local universities and approximately equal numbers were enrolled in overseas institutions. *Table 2.2* shows enrolments by state and by level of education in 1991. Enrolments are greatest in Johore, Perak, Selangor and Sabah and Sarawak.

Table 2.1. Population, enrolment and gross enrolment ratios by level of education for the year 1990

Gross Level	Age group	Population	Enrolment	Ratio
Primary	6+ - 11+	2,451,800	2,447,206	99.8 %
L. Sec.	12+ - 15+	1,135,300	942,801	83.0 %
U. Sec.	16+ - 17+	735,500	361,411	49.1 %

Source : Ministry of Education, Malaysia, 1990, Unpublished Statistics, Educational Planning and Research Division (EPRD).

Table 2.2. Enrolment by state and level of education for the year 1991

Level State	Primary	Lower Secondary	Upper Secondary	Form Six	Total
Johor	299,244	118,389	43,675	6,100	467,408
Kedah	197,187	68,028	26,942	6123	298,280
Kelantan	1,987,931	55,580	27,025	5,524	275,060
Melaka	73,229	33,614	14,324	2,645	123,812
N.Sembilan	197,830	44,363	18,563	3,063	172,819
Pahang	168,122	57,235	22,985	3,134	251,476
Perak	287,573	127,039	45,328	7,753	467,693
Perlis	26,234	9,948	4,606	1,138	41,926
Pulau Pinang	132,382	63,216	23,505	4,367	223,470
Sabah	243,551	77,727	28,123	2,910	352,311
Sarawak	227,989	86,934	31,489	5,449	351,861
Selangor	308,856	111,799	37,012	5,011	462,678
Terengganu	123,422	37,583	15,947	2,702	179,654
Wilayah Persekutuan	148,265	61,690	23,781	3,484	237,220
Total	2,530,815	953,145	363,305	59,403	3,906,668

Source : Ministry of Education, Malaysia. Adapted from Educational Statistics in Malaysia 1984-90. Unplished Statistics (1991). (EPRD)

2.2 Patterns of enrolment

Lower secondary schools offer a comprehensive education in which there is no streaming according to specialisation though some schools stream by ability. All pupils study a common science syllabus. Total enrolments at the lower secondary level increased by 117,514 (14.1 per cent) from 835,631 in 1981 to 953,145 in 1991. With the exception of 1988, enrolment increased for every year in the period. The rate of growth was greater in the first half of the decade, when it averaged 2.4 per cent per annum, than in the later half when it grew by only 0.2 per cent per annum. There is little disparity in enrolments by sex at this level.

Table 2.3. Secondary enrolment by year and sex for the years 1981-1991

Enrolment Year	Male	Female	Total	Percentage change in enrolment
1981	433129	402502	835631	-
1982	439068	411232	850300	1.8 %
1983	450105	422056	872161	2.6 %
1984	462056	437313	899369	3.1 %
1985	470599	447638	918237	2.1 %
1986	479128	456137	935265	1.9 %
1987	476790	460554	937344	0.2 %
1988	471872	459925	931797	-0.6 %
1989	473228	456290	938518	0.7 %
1990	473999	468802	942801	0.5 %
1991	478489	474656	953145	1.1 %

Source : Ministry of Education, Malaysia. Adapted form Educational Statistics in Malaysia 1984-90. Unpublished Statistics (1991). EPRD.

Analysis of lower secondary enrolment by school location for 1989 indicates a slightly larger percentage of students in rural schools (51 per cent) than urban schools. In rural schools 52 per cent of students at this level were male, compared to 50 per cent in urban schools. In 1989, the largest enrolments were in the states of Perak, Johor and Selangor. Perlis had the smallest enrolment while Sarawak and Sabah had enrolments smaller than that of Selangor but larger than those of the other states in Peninsular Malaysia.

Table 2.4 below gives a summary of the transition rates from Form III to Form IV for the period 1984/85 to 1990/1991. The overall transition rate from Form III to Form IV has averaged about 66 per cent annually, with little disparity between sexes. Since 1986 the transition rate of females has exceeded that of males for government schools. However, the transition rate from Form III to Form IV Science decreased from 1985 to 1991.

Table 2.4. Summary of transition rates from form III to form IV (1984/1985 - 1990/1991)

Transition Form III	from to Form IV	1984/ 1985	1985/ 1986	1986/ 1987	1987/ 1988	1988/ 1989	1989/ 1990	1990/ 1991
Form IV	Male	66.2	68.1	64.5	64.1	65.2	66.3	66.9
	Female	64.1	66.9	67.7	66.1	67.8	68.0	69.0
	Overall	65.2	67.5	66.0	65.1	66.5	67.2	67.9
Form IV Science	Male	20.9	21.0	18.6	16.6	16.6	16.0	12.9
	Female	18.4	19.1	17.5	15.9	15.6	14.6	11.5
	Overall	19.7	20.1	18.0	16.2	16.1	15.3	12.2
Form IV Arts	Male	39.7	40.7	39.3	40.6	40.3	41.2	43.8
	Female	43.5	45.5	47.9	48.0	49.5	50.6	54.3
	Overall	41.6	43.1	43.6	44.3	44.9	45.9	49.1
Form IV Tech.	Male	1.5	1.4	4.4	1.2	1.3	1.3	1.2
	Female	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Overall	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Form IV Voc.	Male	4.1	5.0	5.0	5.6	7.0	7.9	9.1
	Female	1.5	1.5	1.6	1.5	2.0	2.1	2.5
	Overall	2.8	3.4	3.4	3.6	4.5	5.0	5.7

Source : Ministry of Education, Malaysia. Adapted from Educational Statistics in Malaysia, 1984-90: Unpublished Statistics, (1991). EPRD.

The drop is larger for males (8.1 per cent) than females ((7.6 per cent). On average between 1984 and 1991 about 17 per cent of the enrolment in Form III proceeded to Form IV Science the following year, 45 per cent to Arts, 1 per cent to the Technical stream and 4 per cent to the Vocational stream.

Between 1981 and 1990 upper secondary enrolments increased by 90,805 (34 per cent) from 270,606 to 361,411 growing at a much greater rate than those at lower secondary level. Enrolment growth was strongest in the earliest part of the decade and averaged less than 1 per cent per annum at the end of the decade. Since 1986 female enrolment has exceeded male enrolment by a small margin. Over the period 1981 to 1990 enrolment of males increased by 34,068 (24 per cent) whilst that of females grew by 56,737 (44 per cent). *Table 2.5* gives figures for upper secondary enrolment by stream for the period 1981-1991. Overall science stream enrolment fluctuated between 1981 and 1986 when it was at a maximum of 99,084.

Table 2.5. Upper secondary enrolment in assisted secondary schools by year and by stream (1981 to 1991)

Stream	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991*
Arts No %	169.893 62.78	166.476 64.90	206.377 67.75	217.436 66.9	211.395 64.68	215.674 64.24	230.797 65.77	240.803 67.03	242.410 67.59	246.370 68.17	251.674 70.78
Sc. No %	82.192 30.37	74.010 28.85	79.947 26.24	88.094 27.14	95.843 29.32	99.084 29.5	97.293 27.73	94.420 26.28	89.366 24.92	84.919 23.49	73.904 20.78
Voc. No %	13.287 4.91	10.861 4.23	12.908 4.24	13.551 4.18	13.987 4.28	15.295 4.56	17.527 4.99	18.846 5.25	21.584 6.02	24.845 6.87	24.471 6.96
Tech No %	5.234 1.93	5.159 2.01	5.388 1.77	5.454 1.68	5.614 1.72	5.649 1.68	5.292 1.51	5.186 1.44	5.248 1.46	5.277 1.46	5.261 1.48
Total	270.606	256.506	304.620	324.535	326.839	335.702	350.909	359.255	358.608	361.411	355.580

Source : Adapted from Ministry of Education, Malaysia, Educational Statistics of Malaysia, 1981-89 ; unpublished Statistics, 1990. EPRD.

* *Note* : Figures for 1991 are provisional figures.

Since then there has been a continuous decline both as a proportion of total enrolment and in absolute numbers. By 1991 science stream enrolment had fallen to 73,904 (provisional figure), which was 25 per cent less than that in 1986 (*Table 2.5*). Technical and vocational enrolments have been increasing since 1987 by modest amounts and together they now make up about 8 per cent of total enrolment. Technical school enrolments have remained almost constant in absolute numbers, whilst vocational school enrolments have nearly doubled between 1981 and 1991.

Table 2.6 shows the pattern of Form IV and Form V science enrolments separately from 1985 to 1991. It shows that the decline in science stream entrants to Form IV has averaged about 4 per cent a year. The largest drop was between 1990 and 1991 when Form IV science shrank by over 21 per cent. As a result by 1991 about 21 per cent of all students in upper secondary were in the science stream compared to nearly 30 per cent in 1986.

Table 2.6 Upper secondary science stream enrolment in Government assisted secondary schools by year and by form (1985 - 1991)

Level	1985	1986	1987	1988	1989	1990	1991*
Form IV % increase	50527 -	52723 4.3%	48952 -7.2%	44922 -8.2 %	43656 -2.8 %	41860 -4.1 %	32998 -21.2 %
Form V % increase	45316 -	46361 2.3%	48341 4.3%	49498 2.4%	45710 -7.7%	43059 -5.8%	40906 -5.0 %

Source : Adapted from Ministry of Education, Malaysia, Educational Statistics of Malaysia, 1985-89 ; Unpublished Statistics, 1990. EPRD.

* *Note* : Figures for 1991 are provisional figures.

Analysis of enrolment by stream and location (*Table 2.7*) for 1989 reveals that the majority (54 per cent) of upper secondary students were in urban schools. In the arts stream, however, the majority of students are to be found in rural schools. This indicates a tendency of rural pupils to be over-represented in the arts stream and under-represented in the science stream. Indeed, while 32 per cent of urban school students were in the science stream, this is the case for only 17 per cent students in the rural schools. The urban-rural disparity in science stream enrolments is of real concern. Male participation exceeded female participation in the science stream between 1981 and 1991. The disparity gradually decreased over the period from 57 per cent to 52 per cent male.

Table 2.7. Upper secondary enrolment in Government assisted secondary schools, by location and by stream (1989)

Stream		Urban	%	Rural	%	Total	%
Arts	No %	115128 59.6	47.5	127282 77.0	52.5	242410 67.60	100
Science	No %	61483 31.8	68.8	27883 16.9	31.2	89366 24.9	100
Tech.	No %	4084 2.1	77.8	1164 0.7	22.2	5248 1.5	100
Voc.	No %	12568 6.5	58.2	9016 5.5	41.8	21584 6.0	100
Total	No %	193263 100	53.9	165345 100	46.1	358608 100	

Source : Ministry of Education, Malaysia, Unpublished Statistics. EPRD.

Comparison of the number of science students by state indicates that science students were concentrated in Perak (25 per cent), Johor (21 per cent), and Selangor (18 per cent). The ratio of arts to science students ranged from 66:34 (Wilayah Persekutuan) to 88:12 (Sabah). In general, the disparity is smallest in the more urbanised west coast states and highest in Sabah and Sarawak. National arts: science ratios (*Table 2.8*) appear to have increased in the period 1980-1990 from 64:36 to 75:25. The largest increase has been observed in Sarawak from 62:38 to 86:14.

The overall transition rates for students from Form V into Form VI are shown in *Table 2.9*. These averaged 17 per cent between 1981 and 1990 and were greater for females.

Table 2.8. Upper secondary arts : science enrolment ratios in assisted secondary schools by state (1980/1985/1990)

State	1990 Enrolment			Arts : Science Ratios		
	Arts	Sc.	Total	1980	1985	1990
Johor	27452	11066	38518	64:36	66:34	71 : 29
Kedah	19752	6076	25828	69:31	74:26	76 : 24
Kelantan	20528	5703	26231	69:31	72:28	78 : 22
Melaka	8833	4028	12861	62:38	64:36	69 : 31
N. Sembilan	11681	4075	15756	63:37	67:33	74 : 26
Pahang	14765	5055	19820	66:34	72:28	75 : 25
Perak	29503	12854	42357	62:38	66:34	70 : 30
Perlis	2442	962	3404	6:39	68:32	72 : 28
P. Pinang	15527	5996	21523	59:41	65:35	72 : 28
Selangor	25463	9451	34914	60:40	66:34	73 : 27
Tarengganu	10324	2753	13077	69:31	71:29	79 : 21
W. Pers.	14272	7514	21786	54:46	59:41	66 : 34
Sarawak	23642	3869	27511	62:38	74:26	86 : 14
Sabah	22186	3149	25335	86:14	86:14	88 : 12
Malaysia	24637	82551	328921	64:36	68:32	75 : 25

Source : Ministry of Education, Malaysia, Unpublished Statistics, 1990; Adapted from Educational Statistics of Malaysia, 1980/85, EPRD.

Table 2.9. Transition rate from form V/form V science to lower VI/lower VI science in assisted secondary schools (1981 to 1990)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Form V to lower VI										
Male	12.66	14.94	16.17	15.84	14.67	13.85	16.13	13.70	13.20	16.06
Female	15.36	17.48	17.75	19.86	17.45	17.95	18.43	19.07	18.70	22.05
Overall	13.93	16.15	16.95	17.82	16.05	15.92	17.31	16.63	15.98	19.13
M - F	-2.70	-2.54	-1.58	-4.02	-2.78	-4.1	-2.3	-5.37	-5.50	-5.99
Form V science to lower VI Science										
Male	20.29	19.39	26.79	25.71	21.97	21.98	23.87	16.63	18.48	23.62
Female	18.11	15.26	22.21	22.34	16.56	17.77	21.76	15.18	16.79	22.52
Overall	19.35	17.57	24.78	24.20	19.53	19.97	22.90	15.95	17.68	23.07
M - F	2.18	4.13	4.58	3.34	5.41	4.21	2.11	1.45	1.69	1.10

Source : Ministry of Education, Malaysia. Adapted from Educational Statistics of Malaysia,1981-1989; Unpublished Statistics, 1990. EPRD.

For the same period the transition rate into Lower VI Science from Form V Science averaged 21 per cent. There, the male transition rate was consistently higher though the differences diminished over time. In 1990 there were 33,976 students in Lower Six. Females accounted for 59 per cent of all sixth form enrolments and 35 per cent of science enrolments in 1989.

Sixth form enrolments have grown continuously over the last decade (*Table 2.10*). The highest growth rates were at the beginning and the end of the 1980s. By 1990, a total of 61,856 students were enrolled in sixth form representing an increase of 32,950 or 114 per cent over 1981. Provisional figures for 1991 indicate a drop in sixth form enrolment of 4,039 (6.5 per cent) over 1990 figures. Students in urban schools form 70 per cent of the total sixth form enrolment and 83 per cent of science enrolment.

Enrolment in the arts stream has increased continuously except for a short period from 1985 to 1987. By contrast enrolment in the science stream has fluctuated with a decline in recent years. Provisional 1991 figures place science stream enrolment at 14,884 compared to 16,101 in 1990, i.e. a 7.6 per cent drop. Whilst science students formed 41 per cent of all sixth form students in 1981, they constituted only 26 per cent in both 1990 and 1991.

The lowest arts:science ratios at sixth form are in the more urbanised west coast states (*see Table 2.11*) and the highest in Kelantan and Sabah. Sarawak had a ratio comparable to the states of Melaka and Negeri Sembilan in Peninsular Malaysia. Ratios for all states have increased from 1980 to 1990 with the largest increases in Sarawak.

In addition to the sixth form there are other avenues of post secondary education including matriculation and pre-university courses which prepare students to meet entry requirements of certain local universities. In 1989, a total of 2,526 students were enrolled in science-based pre-university/ matriculation courses. This represented about 5 per cent of the enrolment in Form V science of the previous year.

Table 2.10. Form VI enrolment in assisted secondary schools by year and stream (1981 - 1990)

Stream	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991 *
Arts No.%	16934 58.58	22249 64.34	25560 63.07	31535 66.20	32655 67.86	32159 67.40	31744 62.89	37677 70.32	41372 74.14	45755 73.97	42935 74.26
Sc. No %	11972 41.42	12332 35.66	14967 36.93	16104 33.80	15468 32.14	15532 32.60	18729 37.10	15901 29.68	14427 25.86	16101 26.03	14884 35.74
Total	28906	34581	40527	47639	48123	47711	50473	53578	55799	61856	57819

Source : Ministry of Education, Malaysia. Adapted from Educational Statistics of Malaysia, 1981 - 1989 ; Unpublished Statistics, 1990, EPRD.

* *Note* : Denotes provisional figures.

Table 2.11. Form VI Arts: science enrolment ratios in assisted secondary schools by year and by state 1980/85/90

State	1990 Enrolment			Arts : Science		
	Arts	Sc.	Total	1980	1985	1990
Johor	4278	2280	6558	55 : 45	65 : 35	65 : 35
Kedah	5468	1099	6567	66 : 34	81 : 19	83 : 17
Kelantan	5207	732	5939	66 : 34	89 : 11	88 : 12
Melaka	2269	716	2985	62 : 38	67 : 33	76 : 24
N. Sembilan	2139	705	2844	59 : 41	70 : 30	75 : 25
Pahang	2737	733	3470	60 : 40	75 : 25	79 : 21
Perak	5150	2984	8134	52 : 48	51 : 49	63 : 37
Perlis	1044	267	1311	78 : 22	83 : 17	80 : 20
P. Pinang	3012	1586	4598	46 : 54	53 : 47	66 : 34
Selangor	3506	1612	5118	66 : 34	64 : 36	69 : 31
Terengganu	2388	392	2780	72 : 28	80 : 20	86 : 14
W. Pers.	2128	1334	3462	46 : 54	58 : 42	64 : 36
Sarawak	3809	1277	5086	42 : 58	59 : 41	75 : 25
Sabah	2663	521	3184	69 : 31	81 : 12	84 : 16
Malaysia	45.799	16.238	62.037	59 : 41	68 : 32	74 : 26

Source : Ministry of Education, Malaysia.unpublished statistics 1990; adapted from educational statistics of Malaysia, 1980/85. EPRD.

2.3 Residential schools

Science Residential Schools (SRS) are a special category of schools aimed at increasing participation and achievement in science education amongst rural and educationally disadvantaged students. These schools have an intake quota of 70 per cent rural to 30 per cent urban students.

There are also state quotas which depend on the number of students who take the Primary School Assessment test (UPSR) in each state, and quotas based on school type. After these have been taken into account, students' performance in the UPSR examination determines which students are offered places. The major intake is at Form I level. Some intake also takes place at Form IV level. In 1989, 91 per cent of upper secondary students in Science Residential Schools (SRS) were in the science stream.

On average about 0.9 per cent of the Form I enrolment is admitted into Science Residential Schools. For 1989 the more rural states of Perlis, Pahang, Terengganu and Kelantan had the most favourable selection ratios into these schools. Sabah and Sarawak had the lowest ratios.

Analysis by sex and by state for the period 1988-1990 shows that the male:female ratio in these schools has averaged 62:38. Male-female enrolment disparities were smallest in Sabah and Sarawak.

Fully Residential Schools (FRS) differ from Science Residential Schools in that they admit students on merit based upon results obtained by students in the UPSR Examination and do not apply quotas for rural students.

While intake is generally at Form I level, students are sometimes admitted at Form IV level based upon results obtained in the Form III Examination (SRP). In June 1989, there were a total of 4,000 students at the upper secondary and sixth form level in Fully Residential Schools representing about 2 per cent of the total enrolment at these levels. Of these, 61 per cent were in the science stream. Male participation exceeded female by 17 per cent in the science stream and by 4 per cent in the arts stream. Arts:science ratios in FRS were 34:66 for upper secondary and 76:24 for the sixth form.

MARA Junior Science Colleges (MJSC) were set up with the objective of helping to increase the participation of Bumiputra (Malays and other indigenous people) in science- and technology-related fields. In these schools students have to take compulsory courses such as Computer Literacy and Thinking Skills not found in other schools. Intake into these colleges is not controlled by the Ministry of Education but by the Secondary Education Division of MARA, a development agency under the Ministry of National and Rural Development.

Since 1988 students have been admitted only at Form IV level. Criteria for entry into the Science stream in MJSCs stipulate a distinction in Mathematics and at least a credit 3 in Integrated Science. For entry into

Management Science, candidates must have obtained a distinction in both Mathematics and Commerce.

In addition to academic criteria, priority is given also to candidates from rural areas. From 1986 to 1990 enrolment in MJSCs increased by 542 (7 per cent) from 7,863 to 8,405 representing a little over 2 per cent of total enrolment at this level. Generally the numbers of males have exceeded those of females.

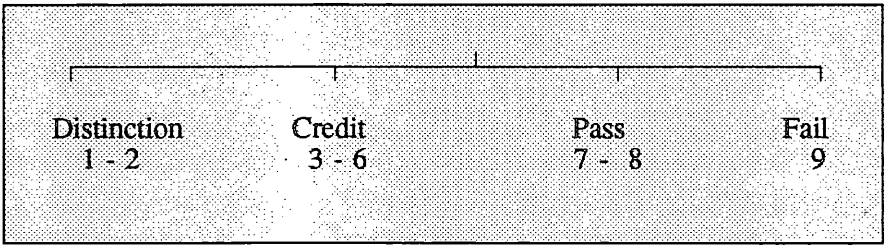
2.4 The allocation and selection of students

Promotion from the primary to lower secondary level is automatic. In the last year of the primary level (Year 6), all students sit for the Ujian Penilaian Sekolah Rendah (UPSR), a primary school assessment examination aimed at assessing mastery of basic skills in reading, writing and mathematics.

The results of the UPSR are used for the selection of students into residential schools which account for somewhat less than 4 per cent of total secondary enrolment. All other students are permitted to progress into Form I, though those from schools where Bahasa Malayu is not the medium of instruction may spend a year in the transitionary 'remove' class.

The Sijil Rendah Pelajaran (SRP) examination takes place at Form III and is used to select students into Form IV of the upper secondary schools. For each subject taken at SRP, students are given grades ranging from 1 to 9. A 1 and 2 are classified as a distinction, 3 to 6 a credit, 7 and 8 a pass, and 9 is a grade denoting failure (*see Chart 2.2*).

Chart 2.2 Subject grades awarded for the SRP examination



Students are awarded 3 overall categories of certificates classified as A, B or C based on the quality of their results. These are judged on the basis of an aggregate score made up of results in the five best subjects drawn from different groups. Current regulations do not make a pass in science a mandatory requirement for the award of certificates in the SRP examination or for entry into Form IV.

Under the old curriculum results of the Form III (SRP) Examination were used for streaming into science and arts streams and for selection into technical and vocational schools. To qualify for the academic science stream students had to possess at least credits in Bahasa Melayu, Science and Mathematics. An additional condition was that the aggregate score had to fall below a set cut off level which was determined each year by the Schools Division of the Ministry of Education depending on the overall performance of all students in the SRP examination. Although a credit in science was required for entry into the science stream, the minimum of credit 6 stipulated was not a very demanding requirement. Currently no pre-conditions with respect to performance in science at SRP level have been imposed on students wishing to take electives from the science group under the new curriculum KBSM. Whilst this new curriculum offers choice of electives, initially all patterns of option choice will not be available in all schools. Over time it is anticipated that promotion from Form III to Form IV will become automatic though a timetable for this has yet to be announced.

Technical schools provide technical education to upper secondary students with the potential to pursue higher education in technical subjects and are being integrated into the general school system. The courses of study offered in technical schools in 1991 were mechanical engineering; civil engineering; agricultural engineering; and commerce. Credits in science and mathematics at SRP level were required for entry into the first three options. Until 1987 vocational schools were essentially terminal and aimed at producing craft and technician level workers. Since then the curriculum has been revised and a new certification system is being devised.

Students should be able to acquire a sufficient academic base along with work-related skills so as to allow a proportion of students to pursue further education if they so desire. Vocational schools offered four areas of study in 1991. These were engineering craftsmanship, home economics, commerce and agriculture. None of these stipulate a credit/pass in science/mathematics at SRP level as critical for entry.

Students in fully assisted government schools take the Sijil Pelajaran Malaysia (SPM) examination at the end of 2 years of upper secondary education (Form V level). Three overall categories of certificates (Grade I, II and III) are awarded based on the quality of performance. Individual subjects are awarded grades ranging from 1 to 9 which are classified into distinctions, credits and passes in the same way as for SRP. A pass in science is not mandatory for the award of certificates at both the SRP (Form III) and SPM (Form V) levels under the new curriculum.

Entry into Form VI in Government-aided schools is dependent upon performance in the SPM examination. For both arts and science streams a credit in Bahasa Melayu is essential. In 1990, entry into the arts and science streams required an aggregate score of 10 and 18 respectively. The aggregate is computed as the sum total of grades for the three best arts or science subjects. For 1991, criteria for entry into the arts stream remained unchanged, while for the science stream the aggregate was tightened to 15.

Thus in both 1990 and 1991 the criteria for entry to Form VI were stiffer for the arts stream than for science. It is also the case that whilst science stream students are not compelled to take or pass science papers in the SPM (Form V) examination, entry requirements for the science stream at sixth form level make it necessary for students to have obtained good levels of achievement in pure science papers in the SPM. Thus only students from the science and technical streams can currently qualify for entry into the Sixth Form Science stream, whilst students from all streams can be admitted into the arts stream. It is not known at present how selection criteria for Form VI will change under the new curriculum.

2.5 Public examinations at lower and upper secondary level

2.5.1 Form III examination (SRP).

The SRP Integrated Science paper taken in Form III consists of 75 multiple choice questions which candidates are required to answer in 1 1/2 hours. The paper is intended to test skills ranging from knowledge and understanding to application and assess some aspects of problem-solving. Recent reports by the Examinations Syndicate on performance in Integrated Science draw attention to several areas in which candidates perform poorly.

These include the understanding and usage of concepts, data analysis, interpretation of graphs, observations and calculations. Candidates perform well on questions based on memorizing facts.

The total number of candidates taking SRP has remained at around 270,000 per year for the period since 1986. Nationally the percentage pass rate for Integrated Science averaged 80 per cent. Overall about 8 per cent of candidates scored distinctions, 29 per cent credits and 44 per cent passes. Generally, the percentage of candidates who obtained passes (Grades 7 and 8) was higher than those who scored distinctions (Grades 1 and 2) and credits (Grades 3-6) put together. Though the pass rate remained fairly constant between 1986 and 1990, the proportions of candidates obtaining pass grades increased and those obtaining credits decreased. In contrast to this general pattern of achievement where passes form the largest proportion of grades obtained, at the MARA Junior Science Colleges the majority of the candidates obtain distinctions. Typically between 60 per cent and 70 per cent of students obtain distinctions and very small numbers obtain bare passes. Students in these schools are highly selected.

2.5.2 Form V examination (SPM)

Table 2.12 below gives the format of the various SPM science subject examinations taken in Form V. Generally, papers at SPM level test a wider range of skills than do those at SRP. This is possible because examination papers requiring essay answers and practical examinations (pure science subjects only) are included.

The number of candidates for SPM science (Physics, Chemistry and Biology) increased from 1986 to 1988 and decreased thereafter. Between 1988 to 1990 there has been a 12 per cent to 13 per cent drop in the number of candidates taking pure science subjects. This is consistent with the drop of 13 per cent in Form V science stream enrolment over the same period. Overall pass rates tended to improve in Biology and Physics but not for Chemistry.

Table 2.12. Format of examination in science at the SPM level

Subject		Paper I	Paper II	Paper III
	Time	1 1/4 hrs	2 1/2 hrs	-
General Science	Total No. of questions	40	Section A: 5 Section B: 6	-
	Type of questions	Multiple Choice	Section A:Structured Section B: Essay	-
	Questions to be answered	All	Section A: All Section B: 2 out of 6	-
	% of total Marks	40 %	60 %	-
Physics/Biology/ Chemistry	Time	1 1/4 hrs	2 1/2 hrs	1 3/4 hrs
	Total No. of questions	40	Section A: 5 Section B: 6	2
	Type of questions	Multiple Choice	Section A: Structured Section B: Essay	Practical
	Questions to be answered	All	Section A: All Section B: 2 out of 6	2
	% of total Marks	40 %	Section A: 30 % Section B: 20 %	10 %

Source : Ministry of Education, Malaysia. Adapted from various sources.

Table 2.13 gives the average distribution of grades for the period 1986 to 1990. Generally, the largest proportion of candidates for pure sciences obtained credits. Performance in General Science for the period 1986 – 1990 has been comparatively low with an average pass rate of about 66 per cent. About 36 per cent of those who passed obtained pass grades only and less than 4 per cent obtained distinctions. Performance of students in science in Fully Residential Schools was generally high. In 1989 the pass rate for all sciences exceeded 95 per cent with General Science having the best performance. Indeed 50 per cent of General Science candidates achieved distinctions in these schools. The proportion of distinctions in the separate science subjects was 15 per cent in Physics and 14 per cent in both Chemistry and Biology. In each case about 65 per cent of the candidates obtained credits. Performance of students in MARA Junior Science Colleges (MJSCs) was generally better than that of students in Science and Fully Residential Schools for the 3 pure sciences. In MJSCs about 25 per cent of students achieved distinctions compared to approximately 15 per cent in Science and Fully Residential Schools. Typically, about 10 per cent obtained simple passes (7-8) in MJSCs compared to about 18 per cent in Science and Fully Residential Schools. The proportion of candidates obtaining distinctions was approximately the same, i.e. 64 per cent.

Table 2.13. Average distribution of grades for pure science, 1986-1990

Subject	Pass Rate (1 - 8)	% Distinctions (1 - 2)	% Credits (3 - 6)	% Passes (7 - 8)
Physics	87 %	10 %	42 %	36 %
Chemistry	80 %	13 %	44 %	23 %
Biology	87 %	9 %	46 %	31 %
General Science	66 %	4 %	26 %	36 %

2.5.3 Form VI examination (STPM)

Table 2.14 shows the format for the various STPM science subject examinations taken at Upper VI level. There is an additional theory paper (3) as compared to SPM science theory papers (2).

While all SPM Physics, Chemistry and Biology papers have the same format, STPM papers differ in terms of weightage of marks for each paper and the choice of questions (Biology being the most restrictive) available. All the science papers, however, have more or less the same total examination time and test a wide range of skills in the essay, structured, multiple choice and practical papers.

Table 2.14 Format of examination in science at STPM level

Subject	Description	Paper 1	Paper II	Paper III	Paper IV
Physics	Time	2½ hours	1¼ hours	1½ hours	3¼ hours
	Total number of questions	Section A: 12 Section B: 5	40	6	2
	Type of questions	Section A: Structured Section B: Essay	Multiple Choice	Essay	Practical
	Number of questions to be answered	Section A: All Section B: 3 out of 6	All	3 out of 6	All
	Total marks	Section A: 46 Section B: 54	60	54	45
Chemistry	Time	7½ hours	1¼ hours	1 hour	3¼ hours
	Total number of questions	Section A: 3 Section B: 5 Section C: 6 Section D: 3	Section A: 5 Section B: 2	40	3
	Type of questions	All essay	Structured	Multiple choice	Practical
	Number of questions to be answered	5 (one each form each section and any other one)	6 out of 7	All	All
	Total marks	100	60	40	50
Biology	Time	2½ hours	2½ hours	1 hour	3 hours
	Total number of questions	9	7	46	3
	Type of questions	Essay	Structurel	Multiple choice	Practical
	Number of questions to be answered	4 out of 9	All	All	All
	Total marks	85	60	40	60

The number of candidates (both government and private) of STPM science varies by subject and by year. Generally, the number of Physics and Chemistry students has decreased since 1987, and for Biology students since 1988. The decrease in the number of Physics students is 23.9 per cent, Chemistry students is 22.7 per cent, and Biology, 21.0 per cent for the periods stated above.

The number of Chemistry and Physics students has been larger for all years (averaging 7,637 and 7,443, respectively, from 1986 to 1990) as compared to Biology students (5,574).

The performance of students in STPM science is as shown in *Table 2.15*.

Table 2.15 Average distribution of grades for pure science, 1986-1990

Performance Subject	Pass rate (A - E)	Grade A - B	Grade C - D	Grade E	Subsidiary	Fail
Physics	42.2	5.2	20.5	16.5	30.5	27.3
Chemistry	60.4	8.7	30.2	21.5	23.0	16.6
Biology	58.5	9.9	30.2	18.4	28.4	13.0

2.6 Developments in science education in Malaysia

The emphasis on science and technology in Malaysian education goes back to the report of the Education Review Committee (1960) which made an explicit commitment to expand and improve the quality of science education. In the 1960s, General Science became a compulsory part of the lower secondary curriculum. The Schools' Regulations (Courses of Study) in 1967 further increased accessibility to science education when it made the teaching of science compulsory at the primary, as well as lower and upper secondary levels of education.

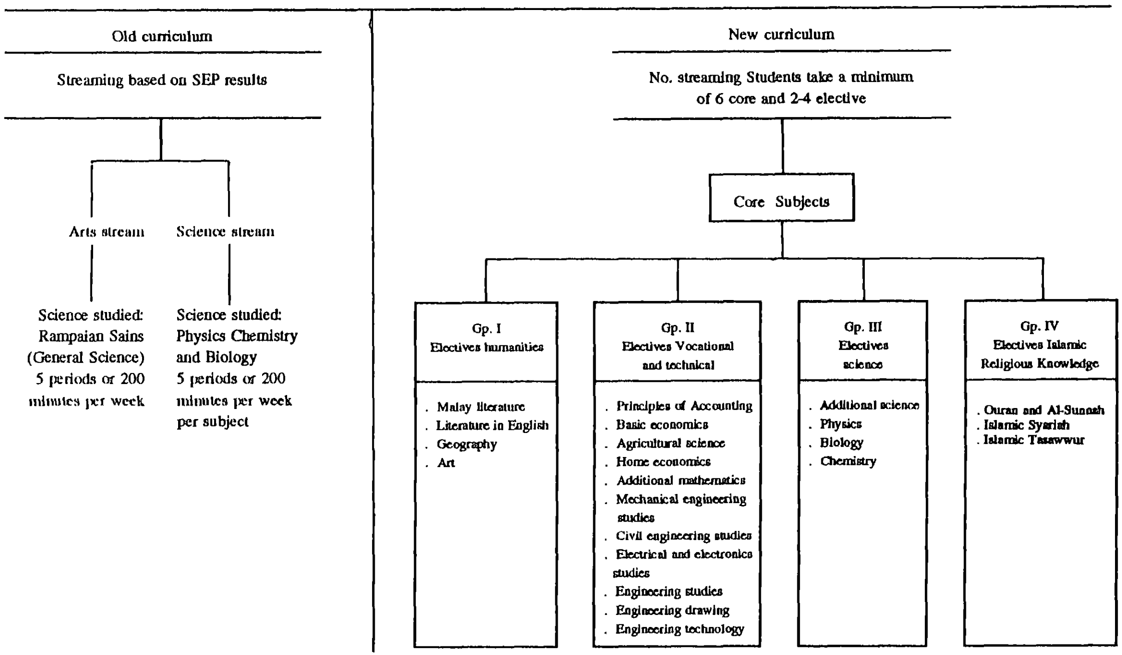
In response to some dissatisfaction with the teaching and learning of science, and the need to update existing courses to reflect recent developments in science, the secondary curriculum was reviewed in the latter part of the 1960s. This began the process of science curriculum development which was to last over the next decade. In the first instance Integrated Science was introduced into Forms I to III based on an adaptation of Scottish Integrated Science to replace the existing General Science programme.

Subsequently the newly formed Curriculum Development Centre developed new science courses for Forms IV and V. In Physics, Chemistry and Biology these were developed from single subject Nuffield Science materials which were being used in England, and a phased introduction began in 1972. For arts stream students a new General Science curriculum was designed, derived from Nuffield Secondary Science from England. This began to be implemented in 1974. These new courses represented a move away from content-based science to more pupil- centred approaches which were intended to utilise guided discovery methods. They included greater stress on practical activity and problem-solving skills than those they replaced. With minor changes these courses came to be known as the Malaysian Syllabus defined by the Malaysian Examinations Syndicate and remained current until the end of the 1980s.

The most recent development in science education is the implementation of the Kurikulum Bersepadu Sekolah Menengah (KBSM) at secondary level. At lower secondary level all students study science for five periods (200 minutes) a week as they did under the old curriculum. At upper secondary level until 1991 students were streamed into arts or science classes on the basis of their performance in the Sijil Rendah Pelajaran (SRP) examinations at the end of Form III. All students studied some science. Rampaian Sains (General Science) was studied by science stream students and three separate sciences (Physics, Biology and Chemistry) were studied by science students (*see Chart 2.3*). Under the KBSM, students at upper secondary level are allowed greater flexibility in the choice of subjects.

All students study a minimum of 6 or 7 core subjects, that is Malay Language, English Language, History, Science, Physical and Health Education, Mathematics and Islamic Religious Education. Special Language subjects – Chinese Language, Tamil Language and Arabic Language (Communication) – are additional subjects allowed for under the KBSM. Students are allowed to take 2 to 4 elective subjects.

Chart 2.3 Comparison of science in the old and new curricula at upper secondary level (1992)



The groups under which electives are offered are Humanities (Group I), Vocational and Technical (Group II) and Science (Group III). In the Science group, Science (Core), Physics, Chemistry, Biology and Additional Science are each allocated 1 period of 10 minutes per week (*see Chart 2.3*). Each subject is allocated 4 periods of 40 minutes per week. Among the conditions governing the selection of electives are as follows:

(i) Electives must be chosen from at least 2 different groups of electives, one of which must be the Vocational and Technical groups of electives;
(ii) Students taking 2 or 3 pure sciences (Biology/Physics/ Chemistry) may not take (a) science offered as a core subject, (b) Additional Science;
(iii) Students in technical schools who opt for 3 pure science subjects are allowed to take a maximum of 5 electives;
(iv) Students taking 2 or 3 pure sciences are allowed to take a maximum of 5 electives.

The KBSM curriculum as a whole emphasises the integrated and harmonious development of students through a balanced diet of subjects and stresses the inculcation of desirable values. Specifically science in the KBSM has a number of general aims. These are to:

- provide students with necessary scientific knowledge – and skills;
- develop in students a scientific way of thinking;
- inculcate desirable moral values.

The new science programmes are structured to enable students to:

- acquire an understanding and knowledge of concepts and principles in science and relate them to everyday experience;
- develop scientific skills so as to be able to apply these skills creatively and intellectually for problem solving;
- understand and appreciate the contribution of science and technology towards enhancing the development and well-being of human beings;
- communicate and discuss clearly and rationally topics related to science and technology;

- develop enquiring minds and interest in science and cultivate and practise scientific values;
- understand issues, practise desirable social values in relation to the application of science and technology, and be able to make responsible decisions;
- develop an awareness that scientific discoveries are products of the human mind which arise from understanding natural phenomena.

At lower secondary level Integrated Science is one of 11 core subjects taught. It is taught through an integrated course using pupil books and teachers' guides for each year. In addition, work books are available from commercial publishers. The course is organized thematically and integrates scientific knowledge and its applications, scientific skills and desirable moral values.

Science is considered to be a 5-year programme that starts at the lower secondary level and continues through to the end of upper secondary. Upper secondary science consists of core, additional and elective subjects. General science is one of seven core subjects for students not taking any, or only one, elective from the science group of electives, comprising Additional science, Physics, Chemistry and Biology. (*See Chart 2.3*). The curricula include teacher's guides and student textbooks. Commercially available workbooks and books of past examination questions are widely used.

2.7 Characteristics of science teachers

In Malaysia, science teachers have followed courses either at University or Teachers' Training College level. In the case of the former, courses are either at Diploma or Degree level, while in the case of the latter they are at certificate level. In all cases teachers specialise both in Science and in Education. Since 1987 Teachers' Training Colleges have stopped training teachers specializing in science in line with the government's long-term plan of having only graduate teachers in secondary schools. In June 1991, two Teachers' Colleges, (Raja Melewar Teachers' Training College in Seremban, Negeri Sembilan and the Federal Teachers' Training College in Pulau Pinang), began a one-year Education Course for about 220 science graduates to prepare them for a career in teaching.

Data from the Malaysian Human Resources Development Plan Project Report on Education (1989) noted that nationally about 18 per cent of all secondary school teachers were involved in the teaching of science. Analysis by state reveals figures ranging from 14 per cent in Sabah to 20 per cent in Wilayah Persekutuan. Of the teachers teaching science about 70 per cent were trained science optionists (*Table 2.16*). There is a wide variation from 53 per cent in Sabah to 77 per cent in Perak. On the whole Sabah and Sarawak had the highest percentage of non-science optionists teaching science. In Peninsular Malaysia the state of Pahang had the highest percentage of non-science optionists teaching science (37 per cent).

As an indicator of the number of science teachers available by state the ratio of trained science teachers to the number of students studying science was computed. It was generally found that states in Peninsular Malaysia had teacher: pupil ratios higher than the national average while Sabah and Sarawak had lower ratios.

In Peninsular Malaysia ratios ranged from 1:129 in Perlis to 1:167 in Perak and Pahang. Ratios for Sabah and Sarawak were 1:300 and 1:242 respectively. The same data revealed that 1,556 or 17 per cent of science optionists were not teaching science in 1989. Analysis by state revealed figures ranging from 12 per cent (Negeri Sembilan) to 24 per cent (Sarawak). Sabah and Sarawak had the highest percentage of Science optionists not teaching Science, 20 per cent and 24 per cent respectively. It must be noted that these two states also had the highest percentage of non-science optionists teaching science. The states of Johor and Perak in Peninsular Malaysia had the largest numbers of science optionists not teaching science, 227 and 229 respectively. This represented 19 per cent and 18 per cent of the number of science optionists in the state.

Table 2.16. Status of teachers teaching science by state

	Teachers Teaching Science				
	Sc. Option (% of total teaching Sc.)	Non science option (% of total teaching Sc.)	Total	* Total No. of students studying science	No. of students Per trained Sc. optionist
Johor	996 (72.2)	383 (27.8)	1.379	156.682 (11.8%)	157
Kedah	593 (68.7)	258 (30.3)	851	96.835 (11.8%)	163
Kelantan	590 (74.0)	207 (26.0)	797	84.531 (10.3%)	143
Melaka	302 (74.2)	105 (25.8)	407	47.362 (5.8%)	157
N. Sembilan	394 (70.0)	169 (30.0)	563	59.737 (7.3%)	152
Pahang	459 (62.7)	273 (37.3)	732	76.482 (9.3%)	167
Perak	1.041 (77.4)	416 (28.6)	1.457	173.625 (21.1%)	167
Perlis	103 (76.9)	31 (23.1)	134	13.317 (1.6%)	129
P. Pinang	547 (74.8)	184 (25.2)	731	86.106 (10.5%)	157
Selangor	857 (75.1)	284 (24.9)	1.141	139.780 (17%)	163
Terengganu	352 (76.0)	111 (24.0)	463	48.067 (5.8%)	137
Wilayah Pers.	533 (71.6)	211 (28.4)	744	83.030 (10.1%)	156
Sabah	331 (52.8)	296 (47.2)	627	99.442 (12.1%)	300
Sarawak	489 (56.1)	382 (43.9)	871	118.187 (14.4%)	242
Total	7.587 (69.6)	3.310 (30.4)	10.897	1.283.183 (100%)	169

Source: Adapted from Malaysia Human Resources Development Plan Project, Report on Education (1990), Economic Planning Unit, Prime Minister's Department.

* Includes all lower secondary and upper secondary students as well as sixth form science stream students.

2.8 Resources and professional support

All secondary schools receive a common per capita grant for the teaching of Science and Mathematics. Rates are dependent upon enrolment at different levels as shown in *Table 2.17*. The per capita grant expenditure is to cover non-salary expenses such as purchase of equipment, consumables, teaching aids and furniture for science as well as for Mathematics. Other categories include the renovation of science laboratories, and the servicing and maintenance of equipment. Special allocations are sometimes made when new courses are introduced. From the school year beginning 1990/1991 the per capita rate was increased for all levels. Increases ranged from 5 per cent to 50 per cent. The current system of allocation does not make special provision for the relative numbers of science and arts students enrolled in upper secondary despite the fact that science students study all three pure sciences while arts students take only Science (core).

Table 2.17. Per capita rate for science and mathematics

Level	Rate per Student per year effective 1990/1991	Old Rate
Remove - Form III	$ 15.00	$10
Form IV - Form V	$ 30.0	$20
Form VI	$ 45.00	$30

Laboratory staff, comprising laboratory assistants and attendants are responsible for the preparation of equipment and the chemical and biological materials required for laboratory lessons; for laboratory cleaning; stock checking; maintenance of equipment and storage of toxic materials. Allocation of laboratory staff to schools is currently dependent upon the number of laboratories available, the presence of pure science stream at upper secondary level and of pure science stream at sixth form level. Laboratory staff are appointed on the basis of their academic qualifications, i.e. passes at SRP (Form III) for Laboratory Attendants and at SPM (Form V) for Laboratory Assistants. No special training is given to them on their appointment and they are posted straight to schools. Laboratory staff may be trained on the job by the academic staff of the schools. Some states have attempted to hold courses for these staff though these have been discontinued due to lack of funds.

The construction of laboratories and supply of equipment to them is under the purview of the Development and Supply Division of the Ministry of Education. The cost of building a Science/Integrated/KBSM Science laboratory is estimated by the Development and Supply Division of the Ministry at M$50,000.00 and for a pure science laboratory at M$65,000.00. The costs of equipping laboratories are estimated to be M$15,000.00 for Integrated/KBSM/Science laboratories and $20,000.00 for pure science laboratories. A basic stock of equipment is provided when laboratories are constructed.

Several divisions of the Ministry of Education are involved in the overall development and supervision of science education. The Federal Inspectorate of Schools is responsible for the supervision of the teaching and learning of science through its science unit. This unit has responsibilities for evaluating the science curriculum, monitoring its implementation, and supervising and improving the quality of teaching and learning in science. The Science Unit of the Schools Division is concerned with the implementation of policies and directives on science education and has direct administrative and managerial responsibilities. The Curriculum Development Centre develops a new science curriculum and also monitors and evaluates it in action.

Supervision of science education at state level is the responsibility of the Science Sub-Unit of the State Curriculum Units. In addition, at district and school levels science teachers' committees have been established to strengthen the implementation of the science curriculum. The role of the Science Sub-Unit is varied and includes the supervision of teaching and learning, the organization of science-related activities, e.g. quizzes, maintenance of records, assistance and advice on the purchase of instruments and the supervision of science practical examinations. One officer is allocated to the Science Sub-Unit of each state regardless of the number of schools. Thus ratios of science officers to schools vary from 1:14 in Perlis to 1:148 in Perak. Contact with schools is most frequently administrative in character and involves the conduct of practical examinations, the running of special events, e.g. science week, and approval of purchases exceeding M$500.00.

2.9 Emerging issues

A number of issues of concern emerge from this Chapter. They will need to be investigated further in the rest of the study. The Malaysian science education system is in transition. Under the KBSM secondary curricula are being revised in all subjects. Organisational changes are being introduced that will increase the choice of options for students studying science. All students will continue to study a common science programme from Form I to Form III. Until 1991 students were streamed into arts and science classes at Form IV and took Science or Physics, Chemistry and Biology respectively. Under the new arrangements a freer choice of options is available. All students will take either core science (the successor to general science), or a combination of additional science or the single subject sciences. How this will be done in practice needs to be monitored closely.

Overall enrolment rates in secondary education are high. Much has been achieved in developing a science education system with broad access and appropriately designed courses. However enrolment and transition patterns illustrate that participation in the science stream has been declining substantially. In 1991, only 21 per cent of students were in the science stream compared to nearly 30 per cent in 1986. This gives grounds for concern. Participation rates amongst rural students, and females at higher levels are another area to be investigated.

Whilst the majority of science stream students achieve examination results above pass level at Form V level (SPM), the majority of arts students only achieve pass grades on the less demanding General Science course.

Though there appear to be sufficient trained science teachers in the education system not all are teaching science and many are not graduate teachers. The future demand for science teacher training should be carefully analyzed.

A wide range of support is available for the development of science education through arrangements for equipment and materials, curriculum development and supervision and inspection at different levels. Capitation allowances are currently not linked directly to the number of science students, but to overall enrolment. This may have to be reconsidered. The ratio of science curriculum officers also varies considerably from state to state and this may have to be revised.

On most parameters discussed (enrolment ratios in science, arts science ratio, ratio of trained science teachers, etc.) there are significant differences between the states in science education participation and support. In general, Sabah and Sarawak appear to be lagging behind in the development of science education.

Chapter 3

Destinations: the supply and demand for science school leavers

This chapter investigates educational opportunities available to students studying science, and examines the flow of these students into higher education and the labour market. The main questions which it addresses are to what extent is the output of the school system in balance with demand from higher educational levels; and are labour market needs for science-qualified school leavers likely to be met in future?

The data for this analysis came from a variety of sources. Statistical information from Ministry data bases was examined, questionnaires were sent to higher education and other training institutions. Projections of new job opportunities and growth in employment were obtained from the Manpower Department of the Ministry of Human Resources, newspaper job advertisements were scrutinised and career structures for science-based officers in public service reviewed. Finally, interviews were conducted with a small selection of admissions officers, academics and employers.

3.1 Flows of students

Table 3.1 provides a summary of the number of students who are taught science in public schools and institutions of higher education and training. At the primary school level, where virtually all are enrolled, pupils experience some science through the teaching of 'Man and The Environment', an integrated curriculum for Primary Year 4 to Year 6. At the lower secondary level where approximately 80 per cent of the population is enrolled, all pupils are taught Integrated Science.

Table 3.1. Students taking science as a percentage of total enrolment and population by levels of education (1989)

Level of education	Type of science curriculum	Enrolment in science	Total enrolment	Total pop.	% enrolment in science
		(a)	(b)	(c)	× 100
a) PRIMARY (6+to 11+year)	Man and the environment	2390920	2390920	2415400	100.0
b) LOWER SECONDARY (12+to14+ years)	Integrated Science (KBSM)	938518	938518	1132600	100.0
c) UPPER SECONDARY (15+to16+ years)	General Science Pure science and science/ technical-based subjects	252365 106243	358608	730500	70.4 29.6
d) POST SECONDARY (17+to18+ years)					
Form 6 Pre-University	Pure science Science-based courses	14427 } 9699 }	}	}	
Higher education/ College		}	}	}	
Polytechnics	Science-based courses	7449 }	}	}	
Teacher training	Science options	139 }	}	}	
Colleges		46400 }	121042 }	736800 }	38.3
ITM	Science-based courses	10888 }	}	}	
TAR College	Science-based courses	3798 }	}	}	
e) UNIVERSITY (19+to24+ years)	Pure science and Science-based courses	22460	53476	2007800	42.0

At the upper secondary level under the old curriculum over 70 per cent of the children were taught General Science while the rest were taught Pure Science in three separate subjects. Thus in 1989 about 35 per cent of the age group studied General science and 15 per cent the separate sciences.

At post secondary level below university there are many types of science-based courses provided by government schools and institutes of higher education and colleges. These courses constitute about 38 per cent of total enrolment at this level and enrol about 6 per cent of the relevant age-group. University level science education accounts for about 1.1 per cent of the relevant age group. The number of science places in further and higher education have been increasing but participation at secondary school in pure science subjects has been falling. The proportion of the age group studying science declines as the level of education increases as might be expected. The ratio of science students to other specialisations is at a minimum in Forms IV and V and increases at post secondary and university levels. In addition to students in government institutions, other students are taught science in private educational institutions both at home and overseas. The total number of these students is estimated to be about 71,000 and the majority are enrolled in Form V and VI. These students cannot be incorporated into the table since no figures are available on how many specialise in science.

The most critical levels of output of science-qualified school leavers are at Form V and Upper VI. It is at these levels that the majority enter the labour market or seek further education and training. For the purposes of this study we have defined school leavers as students who leave the normal school system after the completion of Form V or Upper VI. There are currently school leavers at Form III level, but these are diminishing in number and will largely disappear when automatic promotion is introduced into upper secondary schools.

Table 3.2 shows Form V and Upper VI enrolment by subject specialization and sex of students. Form V enrolment includes students in normal, residential and religious schools. Enrolment in the arts stream is about 2.5 times that in science.

Altogether about 205,000 students completed Form V and Form VI in government schools in 1989. A majority of these entered further and higher education or employment, including 2,536 students who were admitted after Form V into matriculation courses at four Universities (those who pass are admitted into degree courses). A certain proportion enrolled in non-MOE private schools to retake examinations to improve grades, or because they did not satisfy entry requirements for continued study in government schools.

Table 3.2. Enrolment in form V and upper VI in government/ government assisted schools in 1989

	Enrolment			
Level	Stream	Male	Female	Total
Form V	Arts Science Vocational Technical	54983 23421 7173 1675	65472 22289 2164 935	120455 45710 9337 2610
	Total	87252	90860	178112
Form VI (Upper)	Arts Science	7966 3279	13541 2398	21507 5677
	Total	10245	15939	27184

Source : Ministry of Education, Malaysia. Educational Statistics of Malaysia, 1989. Educational Planning and Research Division.

The data on private school enrolments is incomplete but some estimates can be made. There are three types of non-MOE secondary schools or 'private schools'.

- Regular private schools cater largely to SRP (Form III), SPM (Form V) and Form VI repeaters, and those who do not fulfil requirements for entry into government schools at sixth form level. In 1989, this group numbered 30,703 and was concentrated at Form V and VI level. In addition, 8,300 were enrolled in elite private schools covering all grades.
- Chinese private schools, the second category, had a total enrolment of 47,493 in 1989. The majority of these students are those who left MOE primary schools at the end of standard six.

- The third category are Islamic religious schools of two types, i.e. normal religious schools and rakyat schools. Statistics for 1988 indicate that enrolment in the former category was 47,042 while that in the latter was 46,977.

Together the elite schools, Chinese private schools and religious schools accommodate 149,812 pupils distributed across all Forms. In 1989, about 15 per cent of the total enrolment in government secondary schools was in Form V and Upper VI. Using this figure as a guide, the number of Form V and Upper VI students enrolled in private schools (excluding regular private schools) can be estimated at about 22,500 students (15 per cent of 149,812).

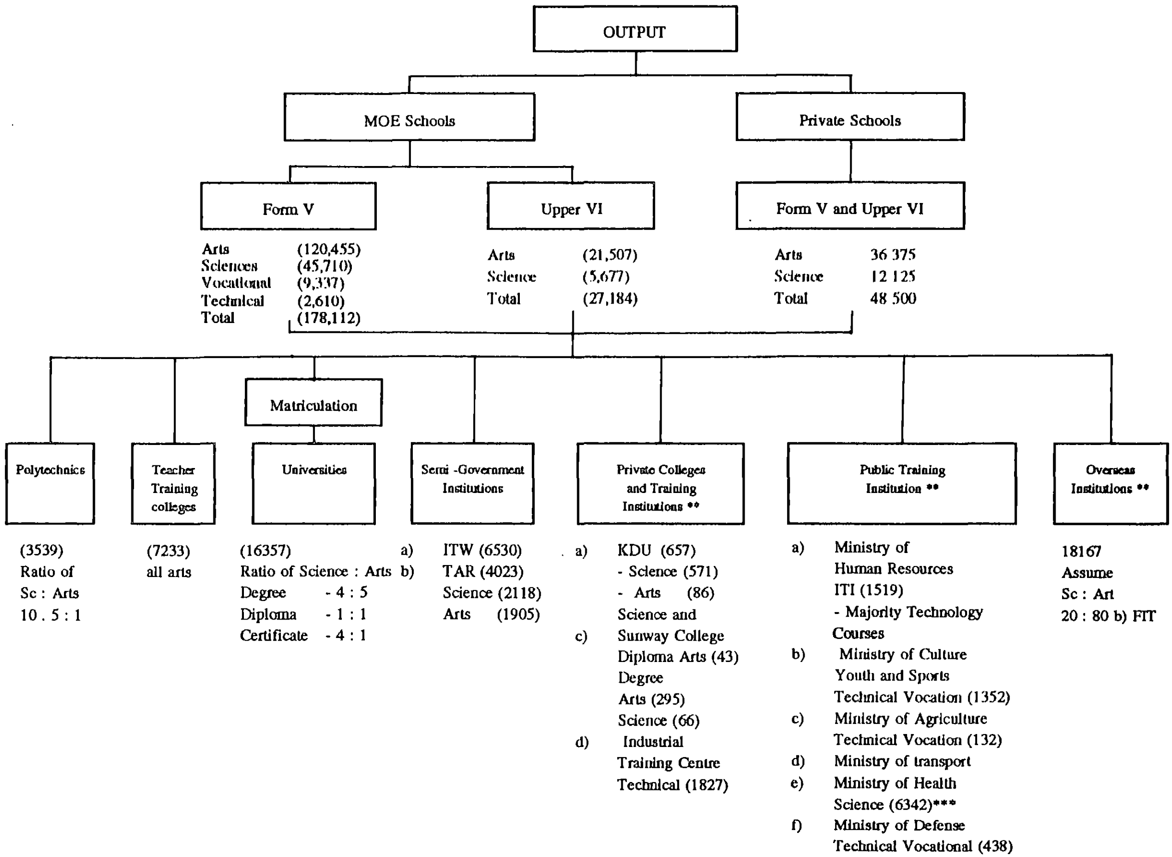
There is no breakdown available of enrolment by Form in regular private schools though these enrolments are concentrated at Form V and Upper VI level. If 70 per cent are assumed to be on one-year courses repeating examinations and the remainder on two-year courses, the total number of school leavers finishing Form V and VI in 1989 in these schools would be approximately 26,000 (30,703 x 0.7 + 9,212/2). Non-MOE schools therefore roughly accounted for 48,500 Form V and Upper VI students.

3.2 Opportunities in higher education and training

Chart 3.1 shows what is known of the flow of students through the school system into institutions of higher learning – the universities (7), polytechnics (6), Teacher Training Colleges (28), the MARA Institute of Technology; the semi autonomous colleges – e.g. Tunku Abdul Rahman College, Damansara Utama College, the Federal Institute of Technology; and into government training agencies under different ministries – Defence, Human Resources, Health, Culture, Youth and Sports. In 1989, the universities admitted 16,357 students, slightly more than half (53 per cent) of whom were arts students. Semi-government institutions admitted a smaller number. The MARA Institute of Technology enrolled 6,530 students and Tunku Abdul Rahman College 4,023.

The polytechnics admitted 3,539 students in 1989 the majority of whom were science and technical stream students. Teacher Training Colleges provide training opportunities for approximately 7,200 potential teachers a year.

Chart 3.1 Destination of school leavers*



Note:

ITM = Institute Technology MARA
TAR = Tunku Abdul Rahman college
KDU = Kolej Damansara Utama
FIT = Federal Institute of Technology

*	Since the chart is based on cross-sectional data for one year it is not a true flow diagram. It does provide an indication of the relative number of places available in science compared to the other areas of study and illustrates the importance of each institution in providing places.
**	Data incomplete for these columns.
***	Indicates number of places available. Data for intake is not available.

Since 1987 these colleges have not enrolled new trainees in science in accordance with the policy that secondary schools should be staffed solely by university graduates.

Public training institutions under different Ministries provide training opportunities for school leavers at skilled and semi-skilled levels. During the Fifth Plan period 111,000 trainees completed their training in such institutions and 58 per cent of these were in engineering trades. Major training programmes relate to the building and printing trades, commerce, agriculture, home science and a wide variety of skills-upgrading courses. In addition, the Ministries of Health and Defence conduct their own training programmes to meet the needs of their respective ministries. It is probable that a majority of these opportunities are better suited to those with a basic grounding in science.

A significant number of school leavers are enrolled in local private institutions which provide degree, diploma and certificate courses in addition to those noted in *Chart 3.1*. The Sixth Malaysia Plan indicates that the enrolment of students in these institutions more than doubled during the period 1985 – 1990, increasing from about 15,000 students in 1985 to about 35,600 students in 1990, with a certificate: diploma: degree ratio of 40:46:14 in 1990. No data is available for the science: arts ratio in such institutions or the breakdown between institutions. It is likely that the majority are arts-based students.

The last group of school leavers is found in institutions of higher learning overseas. The majority are private students who do not register with government agencies. The Sixth Malaysia Plan estimates that in 1990 the total enrolment overseas was 52,000, a drop of 2,500 from the estimated figure projected for 1990 in the Fifth Plan. This drop probably reflects the increasing costs of financing education at overseas institutions and the growing number of local private institutions offering twinning programmes.

Table 3.3 shows enrolment in local public institutions of higher learning offering certificate, diploma and degree courses for 1985 and 1990. Total enrolment increased between 1985 and 1990 at all levels of study. The ratio of certificate:diploma:degree courses changed from 10:36:54 in 1985 to 10:29:62 in 1990. There has therefore been a decrease in the proportion of students enrolled in diploma courses and an increase in those enrolled in degree courses. Though diploma courses were intended to expand faster than degree courses under the Fifth Malaysia Plan the reverse has occurred reflecting strong demand for the latter.

Table 3.3. Enrolment in local public institutions of Higher learning in Malaysia by area and level of study 1985 and 1990

Area	Level	1985 Enrolment	1985 %	1990 Enrolment	1990 %
Science	Degree	12325	69.4 %	16452	77.6 %
	Diploma	5437	30.6 %	4746	22.4 %
	Certificate	0	0 %	12	neg
	Total	17762	100.0 %	21210	100.0 %
Technical	Degree	5156	28.9 %	8910	36.6 %
	Diploma	6787	38.0 %	8332	34.2 %
	Certificate	5895	33.1 %	7103	29.2 %
	Total	17838	100.0 %	24345	100.0 %
Arts	Degree	20357	59.6 %	34649	67.1 %
	Diploma	12822	37.5 %	14925	28.9 %
	Certificate	983	2.9 %	2060	4.0 %
	Total	34162	100.0 %	51634	100.0 %
Overall	Degree	37838	54.2 %	60011	61.7 %
	Diploma	25046	35.9 %	28004	28.8 %
	Certificate	6878	9.9 %	9175	9.5 %
	Total	69762	100.0 %	97190	100.0 %

Source : Prime Minister's Department Malaysia, 1991. Adapted from an unpublished draft of the Sixth Malaysia Plan. Economic Planning Unit.

Degree courses predominate in science with 78 per cent of total enrolment. Between 1985 and 1990 the number of science places expanded by 19 per cent. Technical studies are fairly evenly distributed between certificate, diploma and degree level, though degree courses have grown fastest and are now the biggest category of enrolment. Enrolment has increased by 36 per cent for technical subjects. By contrast, enrolment in arts-based courses has grown by more than 51 per cent, again with a concentration on degree level courses. Science:arts ratios decreased at all levels between 1985 and 1990 (*Table 3.4*).

Table 3.4. Science/technical : arts enrolment ratios by level of study 1985 and 1990

Year	Science/technical : arts enrolment ratio			
	Degree	Diploma	Certificate	Overall
1985	46 : 54	49 : 51	86 : 14	51 : 49
1990	42 : 58	47 : 53	77 : 23	47 : 53

Source : Prime Minister's Department Malaysia, 1991. Adapted from an unpublished draft of the Sixth Malaysia Plan.

A comparison of intake targets and actual total enrolment patterns for degree courses in science for 1985 and 1990 is shown in *Table 3.5*. Whilst intake targets indicate an intended shift in emphasis from pure to applied science, this was not reflected in actual enrolment patterns. Enrolments for 1990 show a shift towards pure science as reflected in the increase in the pure:applied science enrolment ratios. It is also to be noted that actual enrolments have increased less rapidly than they were meant to (less than the intake targets).

Table 3.5. Intake targets and actual enrolment for degree level courses in science, 1985 and 1990

	Intake target		Actual enrolment	
	1985	1990	1985	1990
Pure science	1051	736	3430	5180
Applied science	3386	7661	8900	11270
Total	4437	8397	12330	15450
Pure science Applied science ratio	24 : 76	9 : 91	27 : 73	33 : 67

Source : Prime Minister's Department Malaysia. Adapted from 5th Malaysian Plan, 1986 and an unpublished draft of 6th Malaysian Plan, 1991, Economic Planning Unit.

3.3 Supply and demand for science school leavers within the education system

It is of central importance to the planning of science education to establish the balance between supply and demand for science-qualified school leavers. School enrolments in science have been dropping whilst the number of places in higher education has been expanding. There may therefore come a time when demand outstrips the supply of suitably qualified applicants. An analysis of the existing data is offered below to establish the current position.

3.3.1 Supply of science school leavers

Table 3.6 provides an estimate of the output of the school system in 1989. It assumes that non-MOE enrolments are split 80:20 between arts and science in full range private schools and estimates that 15 per cent of private enrolments in Form V and VI are enrolled in Form VI for both arts and science. Total output competing for places in further education and training is not simply the sum of public and private enrolments at the different levels. A proportion of Form V students from government schools enter private schools to retake SPM – say 50 per cent of those in private schools at Form V. Another group enter Form VI in public or private schools – say 25 per cent of all Form V students. Some Form VI students in public schools enter private schools to retake examinations – say 15 per cent of private enrolment at this level. These students remain enrolled at school level until they complete their courses. Taking this into account leads to the adjusted total 1 in *Table 3.6.*

A further adjustment is necessary to account for the fact that not all students in the graduating cohort obtain examination passes sufficient to apply for further and higher education. If say 30 per cent of students ultimately fail or obtain very low grades the number of potential applicants for higher levels of education and training will be as shown in the adjusted total 2 in *Table 3.6.* This provides the best current estimate of the number of students leaving the school system likely to be qualified to take courses at higher levels.

Table 3.6. Form V and Form VI students in public and private institutions 1989

School Type	Stream	Science		Arts		Total	
		Form V	Upper VI	Form V	Upper VI	Form V	Upper VI
i) MOE Schools							
General		45710	5677	120455	21507	166165	27184
Technical		2610	-	-	-	2610	-
Vocational		9337				9337	
ii) Non-MOE schools		8245	1455	32980	5820	41225	7275
Private schools (SPM and STPM)							
Total		65902	7132	153435	27327	219337	34459
Adjusted Total 1		47365	6281	106832	24101	154197	30382
Adjusted Total 2		33155	4397	74782	16870	107937	21267

Source : Adapted from various sources.

A useful cross-check on the plausibility of this estimate can be obtained by comparing the estimates of adjusted total 2 with statistics on examination entrants. In 1989, there were about 43,000 entrants for SPM pure science examinations and about 6,000 at Upper VI level. These figures can be compared to our adjusted total 2 of 33,155 science-qualified leavers at Form V and 4,397 at Upper VI. Most of the difference arises from the proportions who fail and who are repeating. Adjusted total 2 is therefore a plausible estimate of current output of those likely to be qualified for further education and training.

3.3.2 Place available in science at higher education level

Places in higher education are estimated on the basis of figures from three sources, i.e. public and private institutions in Malaysia and those overseas. *Table 3.7* shows places taken up in 1990 based on enrolment estimates in the Sixth Malaysia Plan. In computing these the science:arts ratio in private sector higher education institutions was assumed to be 25:75 since science education is expensive and most private courses concentrate on other areas.

As *Table 3.7* indicates, local public institutions are the main source (52 per cent) of opportunities followed by overseas institutions (29 per cent) and local private institutions (19 per cent). The largest number of places are for degree level course which account for 55 per cent of the total, the smallest for certificate level (17 per cent). Local public institutions account for approximately 58 per cent of the places at degree level, and local private institutions contribute about 5 per cent. There is a high demand for degree courses overseas.

In science 43 per cent of places are at degree level, 35 per cent at certificate level and 22 per cent at diploma level. At degree and diploma level over 70 per cent of places are provided locally. At certificate level most places appear to be provided overseas. Of the total places accounted for in science, local public institutions provide 57 per cent and overseas and local private institutions account for 34 per cent and 9 per cent respectively. Of the science-related opportunities in local public institutions, 56 per cent are in degree level courses and 29 per cent in diploma level courses.

Table 3.7 Opportunities available for higher education, 1990

Institutions	Science			Arts			Total		
	Cert.	Dip.	Deg.	Cert.	Dip.	Deg.	Cert.	Dip.	Deg.
i) Local public	2373	4363	8457	687	4973	11553	3060	9336	20010
Institutions	949	1092	332	3798	4367	1329	4747	5459	1661
ii) Local Private	5814	509	2543	2326	2034	10174	2907	2543	12717
Institutions*									
iii) Overseas									
Institutions**									
Total	9136	5964	11332	6811	11374	23056	10714	17338	34388

Source : Adapted from various sources.

* More places may be available in private institutions since not all may be registered.

** Places overseas are indefinite in number; these figures refer to the numbers known to be taking courses and on whom information is available.

3.3.3. Balance between supply and demand for science-qualified school leavers

Table 3.8 compares estimates of the output of school leavers likely to be qualified for higher education and training with the number of places available and filled in 1990. From this it is clear that science students enjoy a more favourable selection ratio. The number of places available in local public institutions is 40 per cent of the estimated output of science students; the figure for arts students is 19 per cent. Overall it appears that places are available for about 70 per cent of science students and 45 per cent of arts students when all sources of supply are included.

These estimates have to be treated with a certain amount of caution. The calculation of qualified school leavers includes assumptions concerning transition rates, private school activity and pass rates that could be refined. Our analysis suggests that though this might alter the estimates in detail it is unlikely to change dramatically the patterns that emerge. The computation of places available could also be improved if more complete data existed, especially from private institutions. Again it seems unlikely that this would substantially change the picture.

Table 3.8. Supply and demand for higher education and training

Demand		Supply			Places as a ratio of total school output	
School Output*		Institutions	Places Available			
Science	Arts		Science	Arts	Science	Arts
		Local Public Only	15.193	17.213	0.40	0.19
		Local Private Only	2.373	9.494	0.06	0.10
		Total Local	17.566	26.707	0.47	0.29
		Overseas	8.866	14.534	0.24	0.16
37552	91652	Total	26.432	41.211	0.70	0.45

Source : Adapted from various sources.

* School output uses adjusted total 2 of *Table 3.6* as the best estimate of the number of school leavers likely to be qualified for higher educaiton and training.

These estimates would also be changed if we took into account the fact that some places in lower level science and technology courses are taken by students from the arts stream with acceptable general science results. Although it is preferable that they should be taken by students with a more thorough grounding in science, this kind of substitution undoubtedly occurs. On the other hand, estimates of science school leavers would have to be reduced if we attempted to account for those who might be qualified for higher education and training but who choose not to take advantage of the opportunities available. This may occur because appropriate courses are not available in a convenient location, students interests lead them away from careers in science based occupations, or family responsibilities preclude further study. Bearing this last set of factors in mind a selection ratio of 0.70 appears to imply that almost all science-qualified leavers who are both able and willing to continue to study on science-based courses are currently needed to fill the places becoming available. This is especially so since this analysis is on 1989 figures. The 1991 cohort of science school leavers is substantially smaller and thus the selection ratio is likely to be even larger.

The analysis is strongly suggestive that demand for science-qualified school leavers is converging with supply. Previous discussion has demonstrated that the number of Form V and VI science students declined by over 20 per cent in the last half of the 1980s. Places available in post school science and technology institutions in Malaysia expanded by approximately 28 per cent between 1985 and 1990 (*Table 3.3*). Thus whilst the supply of science-qualified leavers has been contracting, demand in educational and training institutions has been expanding. Future plans (see below) anticipate continued growth in demand for science-qualified leavers and this may exceed output levels unless steps are taken to increase the supply.

The data also suggest that science students have far more opportunity to follow post school courses and obtain higher qualifications than arts students since selection ratios are more favourable. Indeed, since science students may enrol on non-science courses, whereas arts students may be precluded from science-based education and training, selection ratios are probably even more favourable for science students than they appear.

3.4 Some current labour market signals

We now turn our attention to signals from the labour market that provide information on the strength of demand for science-qualified school leavers. An indication of the current labour market situation can be obtained by investigating vacancies reported to the government by various agencies. Though these do not account for all vacancies since an indeterminate number are not notified, they provide the best available source of data. The Manpower Department of the Ministry of Human Resources noted that there were 48,033 vacancies reported for non-graduates in the period January – November, 1990 (*See Table 3.9*). The manufacturing sector was the main generator of notified vacancies in 1990, accounting for 64 per cent of the total and the service sector reported the second largest number of new vacancies (26 per cent).

Table 3.9. Vacancies reported to the Manpower Department by economic sector (non-graduates), 1989-1990

Sector	1989	1990
	Vacancies	Vacancies
Agriculture	4052	2498
Mining	247	196
Manufacturing	38761	30878
Construction	1797	1435
Services	12450	13026
Total	57307	48033

Source : Adapted from Ministry of Human Resources, Malaysia « Trend Gunatenaga », January 1991 (Vol. 6) Manpower Department.

Table 3.10 shows new job vacancies for graduates and diploma holders. These include both those reported to the Manpower Department as well as those advertised in major newspapers for the first 11 months of 1990. Vacancies rose by 19 per cent to 21,650 in 1990 as against

18,144 during the corresponding period in 1989. An analysis of vacancies as shown in *Table 3.10* suggests that science-based occupational groups contributed about 50 per cent of the job vacancies for graduates and diploma holders in the first eleven months of 1990. Data from previous years suggest that graduates and diploma holders with engineering, building and construction, and computer science backgrounds were in increasing demand at the beginning of the 1990s.

Table 3.10. Distribution of vacancies by major category of occupation. (Graduates/diploma holders only) *

Occupational Group	Year				
	1989 (Jan-Nov)		1990 (Jan-Nov)		Annual Rate of change (Percent)
	No. of Vacancies	% Contribution	No. of Vacancies	% Contribution	
Engineering	5322	29.3	7245	33.5	36.1
Administration/ Management	3842	21.2	3923	18.1	2.1
Marketing and Sales	2084	11.4	2160	10.0	4.7
Economy & Finance	1351	7.4	1780	8.2	31.8
Building and Construction	1113	6.1	1521	7.0	36.7
Computers and Statistics	1049	5.8	1488	6.9	41.8
Science and Technology	360	2.0	427	2.0	18.6
Medicine & Health	268	1.5	216	1.0	-19.4
Education	418	2.3	462	2.1	10.5
Others	2357	13.0	2428	11.2	3.0
Total	18144	100.0	21650	100.0	19.3

Source : Ministry of Human Resources, Malaysia « Trend Gunatenaga », January 1991 (vol6), Manpower Department.

* Based on Vacancies reported to the Manpower Department and advertised in the major newspapers.

The 'Trend Gunatenaga' (Employment Trends), January, 1991, indicates increasing disparity in supply and demand situation for science-based occupations. This is especially so for engineering-based careers. In the Medicine and Health group the Manpower Department reported no job seekers reflecting what could be a shortage of manpower in this category.

Table 3.11 presents data on job vacancies by area of specialisation, based on job advertisements surveyed by the Manpower Department. While 52 per cent of total job vacancies fall under the science and technology category only, 3 per cent of this appears to consist of jobs in pure science as compared to 48 per cent in the applied sciences. Thus, as shown by the earlier analysis of flows of students, those pursuing applied science, especially engineering, are likely to have a greater probability of securing employment when compared to those doing pure science.

Table 3.11. Job advertisements by area of specialisation, 1990

Area of specialization	Ist Quarter (Jan-April)	2nd Quarter (May-August)	3rd Quarter (Sept-Dec)	Total %
Pure Science	243	174	303	720 (3.0)
Technology	3568	4103	3881	11552 (47.9)
Arts	1447	1668	1521	4636 (19.2)
Sales/Marketing/ Finance	1468	1592	1505	4565 (19.0)
Others	844	979	794	2617 (10.9)
Total	7570	8516	8004	24086 (100.0)

Source : Adapted from Manpower Department Data, 1990.

Table 3.12 shows our analysis of job advertisements classified by level of qualification required as advertised in major newspapers during the month of April, 1991. Of the 383 job advertisements, 41 per cent (157) required Form V SPM/SPVM/STPM qualifications while 28 per cent (107) required degree level qualifications. Fifty-five per cent of the job advertisements for degree holders required candidates with science/ technology specializations.

Table 3.12 Job advertisement in major newspapers during the month of April 1991, by area of specialization and level of qualification

Level of qualification	Science/ technical	Arts	Others*	Total %
SPM/SPVM/STPM	38	58	61	157 (41.0)
Polytechnic certificate	25	-	6	31 (8.1)
Diploma	36	35	17	88 (22.9)
Degree	59	23	25	107 (28.0)
Total	158	116	109	383 (100.0)

* Sales, accounting and finance.

The figures for diploma, polytechnic and SPM/SPVM/STPM level are 41 per cent, 80 per cent and 24 per cent respectively. At SPM/SPVM/STPM level 40 per cent of advertisements were for jobs in sales, accounting and finance-related areas that generally require applied arts qualifications although those with science qualifications are not precluded.

The overall picture that arises from data on job vacancies therefore suggests that there is substantial demand for science- and technology-qualified personnel. This appears strongest for those with applied science qualifications. Notified vacancies for graduates are largest for engineers and have been increasing in number.

3.5 Growth of job opportunities in science-related areas

The pattern of employment in Malaysia has changed substantially as development has taken place. Growth in manufacturing was identified as a strategic priority for the achievement of the goals of the New Economic Policy (NEP) after 1971. As well as contributing directly to economic growth it was considered vital in efforts to limit growth in urban unemployment and absorb rural migrants into higher productivity occupations. During the Fifth Malaysia Plan period, manufacturing was the leading growth sector in the economy as well as the largest in terms of employment creation. In the Sixth Malaysia Plan, which covers the period 1991-95, this trend is expected to accelerate and it is envisaged that manufacturing will generate about 408,900 new jobs over the five-year period, fully one third of the total new employment to be created. Scientific and technological skills are of value at all levels in manufacturing from the development and design of new products, quality control and innovation in production, and in marketing.

Planned structural changes in the economy will also lead to more jobs being created in the service sector, particularly in non-government services given the policy to reduce the share of total employment in the public sector. During the Sixth Malaysia Plan period, the service sector is expected to generate 593,900 new jobs or 53 per cent of total new job creation. A significant portion of these jobs are expected to be science- and technically-based. The sector includes service industries that deal with electricity, gas, water, petroleum, road and railway, civil aviation, shipping, posts and telecommunications etc. Construction is another sector which is expected to expand substantially: 120,000 new jobs are anticipated which will account for 10 per cent of the total planned growth in employment of 1.1 million. Construction workers include civil engineering workers and a wide variety of trades which have a scientific and technological base (electricians, plumbers, etc).

Though agriculture has been the mainstay of the Malaysian economy its employment share declined sharply from 37 per cent of total employment in 1980 to less than 30 per cent in 1990. It is expected to drop further to 20 per cent by the year 2000. Despite this relative decline, agriculture will remain one of the largest sectors of employment and will increasingly utilise new technologies which are biologically and chemically based. Recent developments in agriculture include ventures into the production of high value-added and market-oriented crops, the use of bio-technology to improve yields, rejuvenating forest and fishery resources using improved management of resources and husbandry, and establishing aquaculture. As agricultural production becomes more technology intensive the demand for research scientists, agriculture extension workers and agro-technicians will increase. Scientific literacy is needed amongst agricultural workers if the benefits of new technologies of production are to be realised.

Current National Development Policy (NDP) aims at the attainment of balanced development in the creation of a just and united society. It emphasizes growth with equity within the context of a rapidly expanding economy. The adoption of the Second Outline Perspective Plan (OPP2) signals the beginning of a policy initiative to make Malaysia a fully developed nation by the year 2020. The Malaysian economy is targeted to grow by an average of 7 per cent per annum for the period of the OPP2 (1991-2000). This is similar to the impressive average growth rate of 6.7 per cent achieved during the 1971-90 period. During the OPP2 the share of manufacturing in the Gross Domestic Product is projected to increase from 27 per cent to about 37 per cent and total employment is anticipated to expand at 3.1 per cent per annum. *Table 3.13* shows the projected occupational structure over the period.

Thus employment growth is planned for all groups except agriculture. Of particular interest is the fact that the professional and technical category is expected to provide 320,000 new jobs during this period, of which 48 per cent will be in scientific and technical occupations. This implies an annual increase of around 15,000 jobs a year for science and technology qualified staff in this category alone. If the annual attrition rate for professional and technical workers is 5 per cent (arising from retirements, deaths, and career changes amongst the existing workforce) about 30,000 vacancies a year will appear of which say 40 per cent are scientific and technically based. This creates an additional demand arising from the need to replace those who have left of 12,000 scientific and technical workers.

The total annual demand of 27,000 can be compared with the current output of science-qualified school leavers estimated above as about 37,000 annually. It implies over 70 per cent of current output needs to be absorbed into scientific and technical jobs in the professional and technical group alone without taking into account science-based staff in all the other occupational groups. It therefore strengthens the view that a shortfall in supply is likely to develop.

Table 3.13. Occupational structure 1990 and 2000

Occupational Group	1990		2000		Net increase 1991-2000		Average annual growth rate % 1991-2000
	(000)	(%)	(000)	(%)	(000)	(%)	
Professional and techn.	580.8	8.8	900.8	10.0	320.0	13.5	4.5
Administrative and managerial	162.4	2.4	263.7	2.9	101.3	4.3	5.0
Clerical	645.9	9.8	891.3	10.0	245.4	10.4	3.3
Sales	761.3	11.5	1243.2	13.8	481.9	20.4	5.0
Services	770.3	11.6	1131.5	12.6	361.2	15.3	3.9
Agriculture	1872.5	28.3	1818.2	20.2	-54.3	-2.3	-0.3
Production	1827.8	27.6	2737.6	30.5	909.8	38.4	4.1
Total	6621.0	10.0	8986.3	100.0	2365.3	100.0	3.1

Source : Prime Minister's Department, Malaysia, 1991. The second outline perspective Plan 1991-2000.

Projections for supply and demand for selected science-based occupations are given in *Table 3.14*. The net increase in employment in these occupations is expected to be 180,394 by the year 2000, a 97 per cent increase over 1990 figures. Of this increase 153,000 (83 per cent) are in the engineering field where shortfalls in supply are projected as most likely for engineers and engineering assistants in civil, mechanical, electrical and electronic engineering. It is also expected that there will be critical skill shortages in some specific industries namely the mould and die industry, the computer industry and the electronics industry as reported in the EPU/ILO/-HRM Project-Critical Skills Study.

Table 3.14. Capacity of local institutions to meet demands for selected professional and technical occupations 1991 - 2000

	Employment		Net Increase	Output	
	1990	2000	1991-2000	Local Public	Local Private
Engineers	26.500	56.600	30.100	21.000	-
Engineering Assistant	72.400	195.300	122.900	84.070	20.900
Medical and Health	11.600	17.600	6.000	6.200	-
Medical and Health Assistants	47.300	57.400	10.100	5.660	1.050
Science/Tech.* Teachers	28.394	39.688	11.294	10.542	-
Total	189.194	366.588	180.394	127.472	21.950

Source : Adapted from, Prime Minister Department, Malaysia, 1991. « The Second Outline Perspective Plan 1991-2000 », EPU and *Ministry of Education, Malaysia, 1991 Teacher Projection 1990-2000, EPRD.

During the Second Outline Perspective Plan efforts will be directed at promoting new sources of growth to strengthen and diversify the industrial base. The orientation towards the development of export-oriented and high technology industries will require strong support from domestic research and development. This implies an increased demand for high level scientists and technologists. The current number of full time research scientists and technologists is approximately 7000, giving a ratio of 400 per million which is low compared to ratios found in industrialised countries. By the year 2000, Malaysia aims to achieve a higher ratio of 1,000 per million population, suggesting that more than 10,000 will need to be trained.

Total employment during the OPP2 period is projected to grow by 3.1 per cent per annum. Virtually all new jobs to be created during this period are expected to be generated in the service, manufacturing and construction sectors. These sectors all depend on an adequate supply of engineers, engineering assistants, technicians and skilled workers. If a 1:4:20 ratio of engineers: engineering assistants: technicians/skilled workers is applied up to 60,000 technicians and skilled workers a year could be needed.

This summary analysis suggests again that demand for science-based school leavers is certain to grow. If the OPP2 planned economic growth rate of 7 per cent is met this would seem to be a minimum growth rate needed for science-qualified school leavers. The restructuring of the economy towards a greater use of science and technology suggests that higher rates are likely to be necessary, perhaps in excess of 10 per cent per year.

3.6 Some insights into levels of satisfaction with science-qualified school leavers

As part of the research a small scale investigation was conducted on the degree of satisfaction of employers and tertiary level institutions with science-qualified school leavers. Among these interviewed were the recruitment officers and/or heads of human resource departments of 2 major employers – a petroleum company and an accounting and auditing firm. Also interviewed were deans, lecturers and academic registrars of a leading university and a polytechnic, as well as principals and registrars of a several private colleges. Some of the main issues that emerged from this small sample were as follows.

University staff in the science and engineering faculties of a leading university believed that the quality of science-qualified students had declined over the last ten years. This view was reinforced by the polytechnic staff interviewed and the principal of one of the private colleges. Evidence given to support this proposition was that entry qualification levels had dropped and more students with lower grades were admitted than previously. In the case of engineering courses at both degree and diploma level it was felt that the best students with good qualifications still had no problems in coping with their coursework. Those meeting minimal qualifications for entry encountered difficulties. In view of this the University had introduced the option to complete the 4-year engineering programme over 8 years on a staggered basis to allow more time to reach the required levels.

A particular criticism in the university and from a private college was that many students from secondary schools were unable to conduct individual laboratory work successfully. This was attributed to too few opportunities to acquire the necessary skills from undertaking practical work at school level.

Poor communication skills were also identified as widely problematic. The principal of one of the private colleges interviewed was concerned that students in his college had inadequate abilities to express ideas orally and in writing in both in Bahasa Melayu and English. Poor written communication skills were evidenced by the number of students who had difficulties in answering subjective questions requiring students to express their ideas in their own words. This was identified as a common problem amongst science and engineering students at tertiary level. This dissatisfaction was echoed by an executive of a large corporation that employs a substantial number of science-qualified personnel. He argued that lack of ability to present effectively ideas affected the opportunities science based employees had to move up the corporate ladder.

Closely related to communication skill difficulties are those identified in the use of the English language. Much of the scientific and technical literature is in English in higher education and in industry. Poor command of the English language was a common complaint noted by many interviewees. This restricted the range of reference material that could be consulted and made the use of instruction manuals a problem. A lecturer at a polytechnic commented that as a result the library was under-utilised and practical training was greatly hampered by the need to translate technical material in detail for students since they could not do this themselves.

In general, most lecturers interviewed expressed satisfaction with the levels of science knowledge which students brought with them on entry into their institutions. However many of those interviewed seemed to have very little detailed knowledge of what was actually taught at secondary level and lacked familiarity with secondary school science curricula and recent developments. From what could be ascertained in the interviews many higher level science and technology courses did not build closely on content and skills which are the focus of secondary science programmes, and coordination of curriculum development between levels seemed unusual.

University and polytechnic staff indicated that engineering students at all levels, (certificate/diploma/degree) generally obtained job offers without much difficulty and the best often received them before they completed their courses. Opportunities for students from the science faculties seemed less freely available and were less lucrative. As a result pure science students appeared to take more time to find employment. Many pure science students seemed to apply for a diploma in education courses in the absence of other opportunities and this resulted in substantially more applicants than the number of places available in at least one institution. However, these were not the best science students.

None of the employers interviewed indicated that there was any discrimination against employing science students for jobs that did not necessarily require science qualifications. Interestingly there were instances where science students were preferred. In the case of the large accounting firm a preference was expressed for science students since it was felt they were likely to be academically superior and have greater numeracy skills.

3.7 Some emerging issues

The analysis presented in this chapter leads to a number of conclusions concerning the flows of students through the science education system and into the labour market. First it is clear that in local higher education institutions opportunities in science and technology predominate for degree level courses rather than those at diploma and certificate level. This pattern has been strengthening. From 1985 to 1990 the degree:diploma ratio increased from 1.4 to 1.9. This occurred despite plans to increase the supply of middle level technical and scientific workers to meet growing demand related to the emergence of more technologically-based industries.

It was also the case that the ratio of pure science to applied science places increased from 27:73 to 33:67 though emphasis is being placed on increasing provision in applied science.

Second, analysis of the supply of science-based school leavers and places available in further and higher education indicates that science-based students enjoy more favourable selection ratios. Places appear to be available for the majority of those completing secondary science successfully. If declining enrolments in science continue a situation will be reached where the supply of science-based school leavers falls below the number of places available at higher levels. This may result in declining admissions standards and/or disproportionate investment in the teaching of basic science in higher education where unit costs are greater than in the school system.

Third, analysis of available labour market information identifies substantial numbers of vacancies for science-qualified school leavers. The largest numbers of notified vacancies are for engineers and demand appears strongest for those with applied science qualifications. Projected numbers of qualified leavers seem too few to meet projected demand in professional and technical occupational categories alone. This is especially the case since our estimates are based on 1989 data since when enrolments have declined further at school level. The smallest cohort will complete Form V in 1993.

Fourth, there is some suggestive evidence that some employers and institutions of higher learning are not satisfied with the quality of science school leavers.

The evidence on this is only suggestive since it was not possible to undertake a thorough review. There do seem sufficient grounds for concern to investigate further to establish what impact this may have on the emerging relationships between supply and demand and the quality of entrants to the labour market.

Fifth, plans for economic growth imply increasing demand for science- and technology-based workers at all levels. Projections suggest that shortfalls are likely to develop for professional and technical staff with scientific backgrounds. This occupational category alone may absorb over 70 per cent of current output, and expansion in employment in other occupational sectors which recruit science-based staff will exacerbate the likelihood of a shortfall emerging. The output of science-qualified school leavers might be expected to grow at more than double the anticipated rate of growth in total employment given the structural changes planned in the economy.

Part II

Science education in practice

Chapter 4

The survey and case study data: an overview

This chapter summarises the main characteristics of the empirical data collected from the schools. The first part outlines details of the survey conducted in four states on schools and science teachers. The second discusses the nature of the case study schools selected from three states for intensive fieldwork. Some preliminary findings are mentioned which prepare the ground for the analysis offered of the data in the next three chapters.

4.1 The survey

4.1.1 Characteristics of schools, principals and teachers

The schools in the main survey sample were selected to be representative of schools in Malaysia in terms of locality and school size. The sample was chosen from all the schools in four states to ease administration and enhance response rates. The sample that was drawn was as shown in *Table 4.1*. Urban schools were slightly over represented but otherwise the sample reflected national distributions fairly closely.

The response rates to the principals' questionnaire were generally satisfactory (*Table 4.2*). In the main sample 75 out of 96 (78 per cent) were returned. The rate of return was 91.7 per cent in Perak, 100 per cent in Terengganu, 92.9 per cent in Wilayah Persekutuan but only 36.4 per cent in Sarawak. The latter arose because the questionnaire had to be postally administered and followed up in Sarawak where distances are large and infrastructure underdeveloped.

Table 4.1 Distribution of sample by state, locality and school size

Locality school Size	State						M'sia Total	%
	Perak	W'yah	T'ganu	S'wak	Total in Sample	% of Sample		
Urban								
500 & less	1	-	1	2	4	4	37	3
501 - 800	1	3	-	1	5	5	57	5
801-1200	4	1	1	3	9	9	116	9
1200-1600	3	3	-	2	8	8	117	12
1601 & more	6	7	-	3	16	17	160	13
Urban total	15	14	2	11	42	44	487	39
Rural								
500 & less	4	-	1	7	12	13	202	16
501 - 800	4	-	3	6	13	14	184	15
801- 1200	7	-	2	5	14	15	213	17
1201-1600	4	-	4	3	11	11	120	10
1601 & more	2	-	1	1	4	4	52	4
Rural total	21	0	11	22	54	56	771	61
Total	36	14	13	33	96	100	1258	100

Table 4.2 Response rate for principal questionnaire by state

State	Number distributed	Number returner	Percentage Returned
Perak	36	33	91.7
Wilayah Persekutuan	14	13	92.9
Terengganu	13	13	100.0
Sarawak	33	16	36.4
Total	96	75	78.1

The overall response rate for the teacher questionnaire was 83.7 per cent (*Table 4.3*). In the West Malaysian sample, (Terengganu, Perak and Wilayah Persekutuan) the average response rate was 88 per cent, while the figure for Sarawak was 66.1 per cent. Teacher questionnaires were received from 35 schools in Perak, 13 in Terengganu, 14 in Wilayah and 20 in Sarawak.

Table 4.3 Response rate for science teacher questionnaires by state

State	Number distributed	Number Returned	Percentage Returned
Perak	429	366	85.3
Terengganu	165	148	89.7
Wilayah Persekutuan	204	186	91.2
Sarawak	183*	121	66.1
Total	981	821	83.7

* Based on estimated number of teachers in main sample schools since actual numbers were not available

The distribution of schools which returned the questionnaires on a range of parameters is given in *Table 4.4*. About 52 per cent of the schools are rural, over 70 per cent cover Forms I to V, and most are mixed schools. Three quarters of the schools are government schools and the remainder are government-aided. In the former, the government gives development grants in addition to supporting recurrent costs. The latter are expected to finance school development themselves.

Table 4.4 Characteristics of responding schools

Parameter	Schools in Sample		Schools in Malaysia	
	No.	%	No.	%
Locality				
Urban	36	48	487	39
Rural	39	52	771	61
School level				
Form I - Form III	7	9.3	263	21
Form I - Form V	54	72.0	699	56
Form I - Form VI	14	18.7	296	24
Students in school				
Boys only	2	2.7	39	3
Girls only	7	9.3	96	8
Mixed (Boys and Girls)	66	88.0	1123	89
Type of assistance				
Government school	57	76	1068	85
Government aided school	18	24	190	15
School grade				
Grade A	29	38.7	435	36
Grade B	46	61.3	823	64
Distance from nearest town				
Less than 5 km	37	49.3	-	-
6 to 25 km	25	33.3	-	-
26 to 100 km	11	14.7	-	-
More tahn 100 km	2	2.7	-	-
Availability of hostel Facilities				
Yes	30	40	427	34
No	45	60	831	66
« Controlled » school				
Yes	11	15.1	-	-
No	62	84.9	-	-
No response	2	-	-	-

Source : Principals' questionnaire.

Grade `A' schools (which normally have hostel facilities and Form VI) made up 39 per cent of the respondents. Forty per cent of the schools have hostel facilities and these are mostly rural schools or urban schools which accept rural students. Controlled schools make up 15 per cent of the schools. In these, enrolment and intake is controlled by the State Departments and it is here that special programmes are generally located (e.g. Rancangan Khas which provides places in high achieving schools for rural students not admitted to fully residential schools).

For the purposes of analysis the school sample was divided into high, medium and low scoring schools. This was achieved by using a weighted score based on SRP (Form III) examination results. Distinctions were weighted 3, credits 2 and passes 1 and an aggregate score computed for each school based on the percentage of candidates falling into each category. The sample was then divided into three parts with approximately the same number of schools in each.

Analysis of the principals' questionnaire shows that the great majority of principals are over 41 years of age. Three quarters are serving in their home state and of these a surprisingly large proportion (45 per cent) were serving in the district where they were born. Of the 74 principals who provided data on themselves in the main sample 77 per cent were graduates but only 10 (14 per cent) were graduates in a science discipline. Most of the science-trained principals are in high and medium performance schools; only 1 was located in a low performance school. The largest numbers of principals were trained as Bahasa Melayu teachers. About 10 per cent of the principals are higher degree (Masters/Ph.D) holders. Over 80 per cent of principals have more than 15 years teaching experience (*Table 4.5*).

All teachers in the survey schools who taught 8 or more periods of science per week were included in the sample. Since not all respondents responded to each question the numbers responding vary slightly on different characteristics. About a third of teachers originated from places in the immediate area of the schools, and somewhat less than a third from other districts in the same state (*Table 4.6*). Teachers teaching secondary science were trained in a number of different subjects and the largest single group was trained in Mathematics. The majority of the remainder were trained in Physics, Chemistry or Biology.

Table 4.5. Main characteristics of principals

Characteristic	% Principals
Gender	
Male	74.3
Female	25.7
Teaching experience (Years)	
Less 5	1.4
5 - 10	6.8
11- 15	10.8
16 - 20	27.0
More 21	54.1
Place of origin	
Local	33.8
Same state-another District	40.5
Another state	25.7
Academic qualification	
HSC/STPM	10.8
Diploma	2.7
First degree	77.0
MA/PHD	9.5
Professional qualification	
Certificate	46.6
Diploma	47.9
Degree	5.5
Main subject trained in	
B. Malaysia	31.1
English/other languages	20.3
History/geography	24.3
Mathematics	4.1
Science	1.4
Physics	4.1
Chemistry	2.7
Biology	5.4
Others	6.8

Source : Principals' questionnaire.

Table 4.6. Main characteristics of the teacher sample

Characteristic	% Teachers
Sex	
Male	44.2
Female	55.8
Place of origin	
Local	35.7
Same state-another	26.0
District	
Another State	38.3
Option Subjects	
KBSM Science	16.9
General Science	8.1
Physics	12.5
Chemistry	17.3
Biology	19.7
Mathematics	20.4
Others	5.0
Locality of school respondent was	
serving in	55.4
Urban	44.6
Rural	

Source : Teachers' questionnaire.

Taken together this accounts for 66 per cent of all teachers teaching science. The relatively small proportion of teachers trained in KBSM Science (the new curriculum) can be attributed to the fact that KBSM is a recent innovation: teachers specifically trained for it will only be those joining recently and teaching the lower forms. All teachers have the opportunity to attend in-service courses for KBSM. Science, which enrols many more students in Forms IV and V than do the separate sciences, appears to have the smallest proportion of science teachers specifically trained in the subject. A majority of the science teachers are located in urban schools (55 per cent). This is consistent with the fact that while there are more rural schools in the main sample the average size of rural schools is smaller.

4.1.2 Enrolment patterns and participation in science in the survey schools

Analysis of the survey data confirms the pattern of declining science enrolment noted in *Chapter 2*. Among the survey schools for which data on enrolment was provided from 1986 to 1990 it is clear that the arts science ratio has been changing in favour of arts students (*Table 4.7*). Whilst science stream numbers dropped by 15 per cent arts stream students increased by 14 per cent. The science:arts ratio declined from 34:66 to 27:73. There was a 43 per cent drop in rural schools in the sample and a 45 per cent drop in low scoring schools suggesting that the swing away from science was strongest in low performing rural schools. Replies to another questionnaire item which asked for statistics on those selected for science in 1989, 1990 and 1991 indicated the same pattern. The numbers selected in rural low and medium performance schools dropped by 23 per cent but by only 2 per cent in urban schools.

Reported transition rates from Form III to Form IV in 1991 are shown in *Table 4.7*. These transition rates are not based on enrolments in successive years but on returns from schools and represent responses to requests for data on promotion into Form IV for the 1990 cohort. They thus take into account repetition and transfer to other schools which simple enrolment figures would not. If anything, the figures are an overestimate since some students selected for science will have subsequently transferred to arts (*see below*).

Table 4.7 Enrolment trends in form IV arts and science, 1986 - 1990

Level	1986	1987	1988	1989	1990
Form IV Science	2852	2845	2713	2658	2431
Form IV Arts	5676	6318	6443	6418	6448
Total	8528	9163	9156	9076	8879
Science:Arts (%)	34 : 66	31 : 69	30 : 70	29 : 71	27 : 73

Source : Principals' questionnaire.

Table 4.8 shows that out of 15,556 candidates in schools in the main sample who sat for SRP in 1990, some 12,038 (77 per cent) were promoted to Form IV of which 8,674 (56 per cent) were streamed into the arts and 2,694 (17 per cent) were selected to do science. About 4 per cent were admitted to Form IV in vocational schools. Of 2,694 science students, those from urban schools numbered 2,104 (78 per cent) while 590 (22 per cent) were from rural schools. Thus 24 per cent of urban students and 9 per cent of rural students were selected for the science stream. More particularly transition rates were lowest in rural low and medium performing schools and urban low performing schools. The differences in the proportions selected for science varied by just over 2:1 for urban high and low scoring schools, but by over 4:1 in rural schools.

In both 1990 and 1991, about 15 per cent of the total enrolment in science requested transfers to the arts stream in the schools for which there was data. About one fifth of students selected for science in urban high scoring schools requested transfers. These students comprised 70 per cent of the total who requested transfers, thus transfer requests are concentrated in these schools. They are also more frequently made by girls. In 1990 and 1991, an average of 24 per cent of girls selected for science in urban schools requested a transfer to the arts stream. In rural schools the figure was 11 per cent. In high performing schools the tendency was most marked with more than 25 per cent of girls requesting transfers. *Table 4.9* shows that requests for transfers decreased by 36 per cent in urban schools, but increased by 8 per cent in rural schools between 1990 and 1991. This occurred when selection for science decreased in both rural and urban schools, partly as a result of tightening entrance criteria.

Table 4.8. Repetition and transition into form IV (1991) by location and school performance in SRP 1990

Location/ performance	Form III Repeaters				1991					
					Form IV Arts		Form IV Science		Form IV Vocational	
	N	1990	No.	%	No.	%	No.	%	No.	%
Urban	34	8887	365	4.1	4414	49.6	2104	23.7	238	2.7
High	19	5428	218	4.0	2801	47.0	1534	28.2	159	0.3
Medium	9	2405	102	4.3	1099	45.7	432	17.9	49	0.7
Low	6	1054	45	2.7	510	48.4	138	13.1	30	0.7
Rural	35	6669	823	4.8	3454	51.7	590	8.6	338	5.0
High	3	577	25	4.3	230	39.9	138	23.9	18	3.1
Medium	12	2548	127	5.0	1202	47.1	264	10.4	152	5.9
Low	20	3544	189	5.3	2022	57.1	188	5.3	168	4.7
Total	69	15556	1188	7.6	8768	56.3	2694	17.2	576	3.7

Source : Principals' questionnaire.

Table 4.9 Requests for transfers into the arts stream, 1990 - 1991

Locality of School	1990			1991		
	M	F	T	M	F	T
Urban	130	340	470	78	221	299
Rural	44	54	98	52	54	106
Total	174	394	568	130	275	405

Table 4.10. Number of science classes in forms IV and V by school performance in the SRP, 1990

School performance	Number of science classes					
	Form IV			Form V		
	None	1	2 or >	None	1	2 or >
High	0	4	17	0	2	19
(N = 21)	0.00	19.05	80.95	0.00	9.52	90.48
Medium	1	10	5	1	7	8
(N = 16)	6.25	62.50	31.25	6.25	43.75	50.00
Low	5	9	1	3	11	1
(N = 15)	33.33	60.00	6.67	20.00	73.33	6.67
Total	6	23	23	4	20	28
(N = 52)	11.54	44.23	44.23	7.69	38.46	53.85

Source : Principals' questionnaire.

4.1.3 Classes and class size

The number of science classes in Form IV and Form V has been declining as the numbers enrolled have shrunk. Between 1990 and 1991 the number of schools in the sample with two or more science classes dropped from 28 to 23; those with one class of science increased from 20 to 23 (*Table 4.10*). Moreover, low performing schools at SRP level are concentrated amongst those which have only one or no Form IV science class. If enrolments decline further more schools will have to discontinue science stream classes in Form IV. Already about two thirds of the schools with one class of science are rural. Class sizes in rural schools are smallest (*Table 4.11*). The average class size in rural schools averaged 23 in Form IV in the sample, whilst urban classes averaged 31.

The data indicate that highest scoring schools have the greatest class sizes. Whatever the effects of class size on achievement, it is clear that relatively large classes do not preclude high achievement. The case for reducing average class size in high scoring schools would therefore seem weak on these grounds. The greater problem seems to lie in improving performance in small classes in rural schools where the risk is that more will fall below the limit of viability and science will cease to be taught as a specialist subject.

Table 4.11 Average class size in form IV and form V science by school performance in SRP, 1990

Locality Performance	Average size			
	N	Form IV	N	Form V
Urban				
High	17	34	18	35
Medium	7	25	7	31
Low	3	22	3	27
Total	27	31	28	34
Rural				
High	3	28	3	32
Medium	8	25	8	26
Low	7	15	9	21
Total	18	23	20	26

Source : Principals' questionnaire.

4.1.4 Science teachers

The overall total number of teachers in the sample schools is a little greater than the formal entitlement based on standard ratios of staffing. It seems that urban schools have about 4 per cent more teachers than their entitlement and rural schools 2 per cent too few. Residential and MRSM (Mara Junior Science College) both have a surplus in terms of their entitlement though this is a small number of teachers in total. The total number of qualified science teachers, the number involved in teaching science, and the ratio of qualified science teachers teaching science to students is given in *Table 4.12.*

Table 4.12 Science teacher : student ratio by school type

School type	Qualified science reachers				
	Total	No. Actually teaching science		Enrolment 1991	Ratio
	(1)	No. (2)	% (3)	(4)	(5)
Day dchools					
- Urban	457	366	80.1	47654	1 : 130
- Rural	315	251	79.7	30107	1 : 120
Residential	305	289	94.8	13645	1 : 47
MRSM	101	101	100	3388	1 : 34
Total	1178	1007	85.5	94794	1 : 94

Source : Principals' questionnaire.
Note : (3) = (2) - (1) x 100
(5) = (2) : (4)

Urban schools tend to have a slightly lower ratio of qualified science teachers to students than do rural schools. This is partly explained by the fact that they tend to have larger class sizes. Within the urban group, high scoring schools had a lower ratio (1:128) than did low scoring schools (1:151). In the rural schools, the converse was true. The ratios in Residential and MRSM (Mara Junior Science College) are 2.5 to 4 times more favourable. It can also be seen from *Table 4.12* that about 80 per cent of qualified science teachers are teaching science in the ordinary schools in the sample. MRSM (Mara Junior Science College) and residential schools show a better utilisation of science-qualified teachers than ordinary day schools.

The number of science teachers teaching at lower and upper secondary levels in rural and urban schools is given by qualification in *Table 4.13* and *4.14*. The proportion of graduate science teachers reached 27 per cent in lower secondary and 78 per cent in upper secondary. At lower secondary level 20 per cent of science teachers in urban schools were graduates compared to 34 per cent in rural schools. This occurs because some rural schools in the sample only have Forms I to III and graduates in these schools have no option but to teach at this level. In larger schools with Forms IV and V they are likely to gravitate to upper secondary classes. There is also less competition for jobs in rural schools so new graduates may find it easier to be posted to them. At upper secondary graduates are concentrated in urban schools where the proportion of graduates reaches 85 per cent compared to 70 per cent in rural schools. Graduates also tend to be concentrated in high scoring schools. The smallest proportion of graduate science teachers is to be found in Form I.

Rural schools appear to experience higher teacher turnover than do urban schools. Out of a total 1,543 teachers in the schools providing data, 168 (11 per cent) were transferred in 1990 of which 39 (3 per cent) were science teachers. In urban schools 143 out of 2054 (7 per cent) were transferred out of which 25 (1 per cent) were science teachers. The replacement ratio for science teachers was greater in urban schools – 1:1.5 compared to 1:1.1 in rural schools. Science teachers were more likely to be replaced in high performing schools.

The survey data outlined above was complemented by detailed investigations in 13 case study schools. The main characteristics of these schools are outlined below.

Table 4.13. Teachers teaching science at lower secondary level by qualification and school performance in the SRP, 1990

Location Performance	No. Training		Cert.		Diploma		Non trained graduate		Graduate		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Urban											
High	3	2.4	80	63.5	16	12.7	0	0	27	21.4	126
Medium	0	0	34	68	8	16	0	0	8	16	50
Low	1	3.7	19	70.4	1	3.7	1	3.7	5	18.5	27
Urban total	4	2.0	133	65.5	25	12.3	1	0.4	40	19.7	203
Rural											
High	0	0	8	24.2	4	12.1	0	0	21	63.6	33
Medium	1	0.9	34	32.1	37	34.9	0	0	34	32.1	106
Low	2	2.3	55	62.5	9	10.2	0	0	22	25	88
Rural total	3	1.3	97	42.7	50	22.0	0	0	77	33.9	227
Total	7	1.6	230	5.5	75	17.4	1	0.2	117	27.2	430

Source : Principals' questionnaire.
Note : Non trained graduate = graduate without training in education.

Table 4.14. Teachers teaching science at upper secondary level by qualification and school performance in the SRP, 1990

Location Performance	No. Training		Cert.		Diploma		Non trained		Graduate		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Urban											
High	0	0	0	0	17	15.3	0	0	94	84.7	111
Medium	0	0	0	0	3	12	0	0	22	88	25
Low	0	0	0	0	3	15	1	5	16	80	20
Urban total	0	0	0	0	23	14.7	1	0.6	132	84.7	156
Rural											
High	0	0	0	0	1	10	0	0	9	90	10
Medium	1	1.9	2	3.7	16	29.6	0	0	36	64.8	54
Low	0	0	4	7.0	13	22.8	0	0	40	70.2	57
Rural total	1	0.8	6	4.9	30	28.1	0	0	85	69.7	122
Total	1	0.4	6	2.2	53	19.1	1	0.4	217	78.1	278

Source : Principals' questionnaire.
Note : Non trained graduate = graduate without training in education.

Table 4.15 Rate of teacher turnover

Locality	Total No. of teachers	Science transferred out	Teachers replacements		Transfer : replacement ratio
		No.	% Turnover	No.	
Urban	2054	25	1.22	37	1 : 1.5
Rural	1543	39	2.53	42	1 : 1.1
Total	3597	64	1.78	79	1 : 1.2

Source : Principals' questionnaire.

4.2 Thirteen schools: case studies

The school case studies were designed to allow intensive fieldwork to investigate how science education was being provided in a range of locations covering the main types of schools. The techniques of condensed fieldwork used to collect first-hand data are described further in the appendix. This section first provides an introduction to the case study schools and then comments on their teachers and changes in enrolment patterns.

4.2.1 The schools

Thirteen schools were selected of which 8 were classified as rural and 5 as urban (*see Table 4.16*). This included 11 ordinary schools, an urban science residential school and a MARA school classified as rural. The majority of the case study schools (85 per cent) are co-educational. Ten of the schools have both science and arts streams at Form IV. Eight were low performing schools, i.e. with performances below the state mean on SRP results.

Table 4.16. Characteristics of case study schools

School	Location	Sess	Level (form)	Sex	Stream	Performance	
						Above/ below State mean	Category of perform-ance
1	R	S	Fm I-V	Coed	A	Below	Low
2	U	D	Rem-Fm V Fm VI	M Coed	S + A S + A	Above	High
3	R	D	Fm I-V	Coed	S + A	Below	Low
4	U	D	Fm I-III	M	-	Below	Low
5	U	D	Fm I-V	Coed	S + A	Below	Low
6**	R	S	Fm IV-V	Coed	S	Above	High
7	R	D	Fm I-V Fm VI	Coed Coed	S + A A	Below	Low
8	R	S	Fm I-V	Coed	A	Below	Low
9	R	D	Fm I-VI	Coed	S + A	Above	High
10	R	D	Fm I-V	Coed	S + A	Below	Low
11	U	D	Fm I-V	F	S + A	Above	High
12	R	D	Fm I-V	Coed	S + A	Below	Low
13*	U	D	Fm I-V	Coed	S + A	Above	High

Note : Session
S = Single
D = Double
* Science Residential school
** MARA school

Location
U = Urban
R = Rural

StreamLevel
A = ArtsRem = Remove
S = Science

The enrolment of the schools (*Table 4.17*) ranges from 494 to 2,598 students with urban schools at both ends of the spectrum. Two schools have enrolments of above 2,000 and both are urban. In most of the schools which were fully co-educational (not including the residential schools) females outnumbered males. In one of the science residential schools, there is a smaller number of female students due to the lack of hostel facilities for girls.

Table 4.17 Teacher/pupil characteristics in case study schools

School	Enrolment			Teacher qualification			Teacher : Pupil Ratio
	M	F	Tot	Gr.	NGr	NT	
1	n . a	n . a	499	12	17	0	1 : 15
2	2402	196	2598	58	47	0	1 : 24
3	628	625	1253	26	42	2	1 : 19
4	494	0	494	5	16	2	1 : 19
5	513	560	1013	30	32	0	1 : 17
6	n . a	n . a	646	73	0	0	1 : 9
7	808	952	1760	42	62	0	1 : 17
8	283	292	575	15	21	2	1 : 16
9	736	768	1504	46	34	0	1 : 17
10	624	712	1336	22	50	6	1 : 17
11	0	2299	2299	42	58	0	1 : 26
12	492	490	982	28	29	8	1 : 16
13	437	290	727	58	13	0	1 : 10

Note :
n.a : Data not available
Gr = Graduate
NGr = Non graduate
NT = Not trained

In four of the 13 case study schools, graduate teachers exceeded non-graduates. These included the two special residential schools and two other high performing schools. The teacher:pupil ratio for the 13 schools ranged from 1:9 to 1:26 with special schools at the lower end of the range and urban schools at the higher end. Schools in depressed urban areas (Schools 4 and 5) had teacher:pupil ratios similar to rural schools. Excluding one of the residential schools, only two schools (2 and 11) had a concentration of students from middle/high socio-economic status backgrounds. These were both urban schools. The pupils of the other schools were predominantly from poor families in the urban squatter areas or from poor agricultural and fishing backgrounds.

It is interesting to note that in the 13 case study schools, 5 did not have a principal in post at the time of the visits. All these schools were rural. In three cases a reappointment had not been made after the previous principal left. In the remaining two cases the principals were attending courses/meetings. If this reflects a more general situation in rural schools it would seem cause for concern. None of the principals were trained in science including those in both the fully residential schools.

4.2.2 Teachers

Four of the schools (31 per cent) did not have a full complement of science teachers when the number of science qualified teachers is compared to the number teaching science (*Table 4.18*). The shortage is most apparent in an urban school located in a squatter area (school 5) which is short of four science teachers and in a rural low performing school (school 8). Shortages are overcome in several ways. In schools where there is an excess of mathematics/statistics trained teachers, these are utilised to teach Physics. In one school, an English Language option teacher was utilised to teach science. In another, 4 out of 11 science teachers were non-science optionists. In contrast several schools had an excess of trained science teachers. In 3 of the schools between 30 per cent and 49 per cent of science optionists do not teach science. School 2 in particular had an excess of 21 science teachers. The majority of these excess teachers teach Mathematics or languages and the remainder teach Agricultural Science, Living Skills and Geography. In 8 of the 13 schools (62 per cent) all teachers teaching science were trained in science (through teacher training, a B.Ed or through a science degree followed by a Diploma). In the other schools the percentage ranged from 50 per cent to 94 per cent.

Table 4.18. Profile of science teachers in case study schools by performance and location

School	Teachers trained in science						Teachers teaching science							
	Teaching science		No. teaching science		Total		Graduates		Non-graduates		Not trained in science		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rural above mean														
9	16	94.1	1	5.9	17	100	7	41.2	9	52.9	1	5.9	17	100
Below mean														
1	4	66.6	2	33.4	6	100	4	100.0	0	0	0	0	4	100
3	15	83.3	3	16.7	18	100	11	73.3	4	26.7	0	0	15	100
7	14	70.0	6	30.0	20	100	4	28.6	10	74.4	0	0	14	100
8	3	100.0	0	0	3	100	2	33.3	1	16.7	3	50.0	6	100
10	11	84.6	2	15.4	13	100	4	36.4	7	63.6	0	0	11	100
12	10	83.3	2	16.7	12	100	3	30.0	7	70.0	0	0	10	100
Urban														
Above mean														
2	22	51.2	21	48.8	43	100	17	77.3	5	22.7	0	0	22	100
11	13	76.9	3	23.1	16	100	5	38.5	8	61.5	0	0	13	100
Below mean														
5	7	100.0	0	0	7	100	5	45.5	2	18.2	4	36.3	11	100
4	4	80.0	1	20.0	5	100	1	20.0	3	60.0	1	20.0	5	100
Special schools														
6	17	100.0	0	0	17	100	17	89.5	0	0	2	10.5	19	100
13	13	100.0	0	0	13	100	12	92.3	1	7.7	0	0	13	100
	149	78.4	41	21.6	190	100	92	57.5	57	35.8	11	6.9	160	100

Note : Above mean = denotes performance above state mean on SRP
Below Mean = denotes performance below state mean on SRP

Graduate science teachers were generally in a minority though graduates account for 58 per cent of all teachers teaching science. This is because graduates are concentrated in particular schools, especially the special science schools, whilst the majority of ordinary schools have less than 50 per cent science graduate teachers. In some, the proportion is as low as 20 per cent. Such schools are more likely to be lower secondary schools and schools with no pure science classes at Form IV. Overall about 22 per cent of science optionists are not teaching science and only 7 per cent of those teaching science are not trained in science. Of the 4 urban schools, both the higher performing schools had 100 per cent trained science teachers teaching science. The other 2 schools which were both in urban depressed areas had some untrained science teachers teaching science. One rural school had half its teachers untrained, but this was the exception.

In the case study schools the overall male:female ratio for science teachers is about 1:1.4. All except two schools have more female science teachers. In many schools there are 2-3 times as many female teachers as there are male teachers. There was one school (School 4) with no male teachers at all. In general, most schools have very experienced teachers and in all but one more than 50 per cent of teachers had more than five years of experience. In half the schools science teachers averaged more than ten years' experience. Staff turnover does not appear to be a major problem in the majority of the schools. On average less than 10 per cent of the staff applied for transfers annually. The main reasons cited for request for transfers were to follow spouses and health or personal reasons. Schools with performances below the mean and located in rural areas seemed to have a higher staff turnover. Indeed the two most extreme cases (Schools 1 and 8) with 30 per cent - 50 per cent turnover, were both small rural schools. Schools in urban areas, irrespective of performance, seemed to have a low teacher turnover. So also did high performing rural schools.

In most of the schools the majority of the teachers taught 21 to 25 teaching periods a week. However, in 3 schools which all had performances below the mean about two thirds of the teachers had a very heavy workload of 26 - 30 periods. Among both rural and urban schools the high performing schools had a smaller percentage of teachers with a heavy workload and, conversely, a higher percentage of teachers with a lighter workload. This was particularly evident in the two science schools.

The average number of science periods taught per week per teacher varied greatly from school to school, i.e. from 12 in some schools to 22 in others. The majority of schools where the science teachers were lightly loaded with science classes were in the low performing category and these were schools with small science enrolments. The special science schools provided a good contrast in terms of teacher workload and utilization. On an average, teachers in these schools taught 17 periods a week of which nearly all were science periods. In terms of the number of subjects taught the majority of science teachers in general secondary schools taught two different subjects of which only one was a science subject.

An assessment of staff morale and motivation was made during the case studies. In general, teachers appeared happy working in their schools. It appeared that most principals allowed teachers to express preferences for the subjects that they liked to teach and tried to accommodate teachers' wishes. They also consulted teachers on decisions regarding time-tabling and extra curricula activities. However, it seemed that most of the science teachers interviewed were not strongly motivated to improve student performance. In most cases teachers attributed poor performance to the poor backgrounds of the students and the weak foundation in science and mathematics students were given at lower levels. Many of the teachers interviewed felt that not much improvement could be achieved unless students' motivation improved and this was seen as largely outside the teacher's control. In only three schools (Schools 2, 6 and 13) was it evident that special efforts were being made to improve performance, and in two of these schools (6 and 13) teachers indicated that they were pressured to produce high achievement since this was expected of their students. School 13 was the school where teacher morale seemed most adversely affected by pressure to get results.

All the schools generally adhered to the guidelines of the Ministry with regard to the number of periods allocated for science. Notable exceptions were Schools 3 and 8 which allotted 6 periods instead of the usual 5 to General Science due to the generally weak performance of students in the subject. School 6, the MARA Junior Science College, included an additional subject Thinking Skills in the curriculum which necessitated the reduction of the number of periods of Chemistry and Physics from 5 to 4 periods per week. School 2 reduced the number of laboratory periods in science to enable more time to be spent on theory for sixth form Physics and Biology. Both special science schools (6 and

13) had introduced new streams of study alongside science and arts. These comprised an Applied Science Stream and a Management Science in the former, and a Social Science Stream in the latter.

4.2.3 Changes in enrolment patterns in science

Table 4.19 shows the science:arts enrolment and class ratios as well as the male:female ratio at upper secondary level in 1990/91. All except one of the general secondary schools had a low science:arts enrolment ratio and there were higher science ratios in higher performing schools. The science:arts enrolment ratio in schools with Form VI was invariably greater than at lower levels. The science:arts class ratio was also low, i.e. on average one science class to every three arts classes. Average class size for the science stream tends to be smaller in the rural schools though there is one case of small class size in an urban school. The urban schools with performance above the mean seem to have much larger class sizes consistent with the earlier finding from the survey. Boys tended to be in a minority in most of the science stream classes in the co-educational case study schools.

The science: arts enrolment ratio in the case study schools has been decreasing for the last 5 years. The biggest drop was from 1990-1991. All case study schools with science streams registered drops ranging from 16 per cent to 49 per cent in Form IV Science enrolment from 1990-91 (*Table 4.20*). This has resulted in the majority of these schools having to close one science class at this level. Evidence in the case study schools indicates that students who qualified for Form IV Science in 1991 had lower SRP aggregates than students of previous years implying stricter selection into the science stream. In some of the urban schools there appeared to be an increase in the number of students who opted out of the science stream. In school 9 decreasing enrolment was attributed to the opening up of science classes in a neighbouring school.

Table 4.19 Science: arts enrolment and class ratios and male: female ratios at upper secondary (form IV and V) level 1990/1991

Location Performance	Enrolment/class				
	Science : arts ratios		Male : Female ratio		Average class size (Sc)
	Enrolment	Class	Science	Art	
General schools Rural					
i) Above x					
9	0 . 4 : 1	0 . 3 : 1	0 . 9 : 1 *		23
ii) Below x					
1	-	No pure sScience streamp			-
3	0 . 1 : 1	0 . 2 : 1	0 .7 : 1	0 . 8 : 1	20
7	0 . 2 : 1	0 . 3 : 1	0 . 7 : 1	0 . 6 : 1	2
8	-	No pure science stream			-
10	0 . 1 : 1	0 . 3 : 1	0 . 9 : 1		
12	0 . 2 : 1	0 . 3 : 1	0 . 8 : 1	0 . 7 : 1	22
Urban					
i) Above x					
2	1 . 7 : 1		All males		4
11	0 . 3 : 1	0 . 4 : 1	All females		39
ii) Below x					
5	0 . 1 : 1	0 . 2 : 1	0 . 6 : 1	0 . 8 : 1	14
4	-	Lower secondary only			-
Special Schools					
Urban					
i) Above x					
6	All science	All science	0 . 6 : 1 *		24
13	2 . 7 : 1	3 : 1	2 . 2 : 1	0 . 8 : 1	28

Note: (i) * Male:female ratios for Schools 6,9 and 10 are not available by stream. Thus figures given represent the overall male female ratio for the upper secondary level.
(ii) Above/below x = Performance above/below the state mean.

Table 4.20 Number and Enrolment of form IV pure science classes in the school, 1990 and 1991

Location/ performance	Enrolment (No. of classes)		
	1990	1991	% Change
General schools Rural			
i) Above x			
9	45 (2)	35 (1)	- 28.9
ii) Below x			
1	No pure science		
3	25 (1)	15 (1)	- 40.0
7	44 (2)	28 (1)	- 36.4
8	No pure science		
10	14 (1)	11 (1)	- 21.4
12	43 (2)	22 (1)	- 48.9
Urban			
i) Above x			
2	209 (5)	162 (4)	- 22.5
11	84 (2)	70 (2)	- 16.7
ii) Below x			
5	16 (1)	11 (1)	- 31.3
4	No pure science (lower secondary)		
Special schools			
i) Above x			
6	Decreasing last 5 years		- 13.1
13	154 (5)	112 (4)	- 27.3

Note : Above/below = Performance above/below state mean.

Performance in examinations in the case study schools varied from year to year. Generally, the quality of performance in science at SRP level (as evidenced by the proportions gaining distinctions, credits and passes) has deteriorated in all but three of the schools. In most schools a very small percentage of students gained distinctions. In rural case study schools on average only 1 per cent of candidates gained distinctions in 1990. Typically overall pass rates were around 80 per cent, though one rural and one urban school had pass rates below 70 per cent.

Performance in Science at the SPM level also seemed to have declined in terms of passes and the proportion of distinctions. In rural schools pass rates were mostly between 60 per cent and 70 per cent. In four of the rural schools none of the students scored a distinction. There also appeared to be a decline in performance in pure science subjects. In these subjects only one of the seven rural schools managed to score any distinctions in 1990. By contrast an urban school (School 2) obtained over 20 per cent distinctions in each of the sciences and in this respect performed as well as the special science schools. Biology and Physics tended to have higher pass rates than Chemistry though the situation varied from school to school. At the STPM level (Form VI), data available for the two schools with pure science classes (Schools 2 and 9) provided two contrasting scenarios. While School 2 (urban) demonstrated a consistently high percentage pass and improving performance, in School 9 at the most only one student passed Physics and Chemistry each year, though more passed Biology. On this small sample there seemed no consistent relationship between performance at SRP and at SPM.

The conduct of internal assessment in all the schools depended heavily on questions modified from past year public examination questions or revision books. These questions were summative in nature and were not obviously designed with diagnostic purposes in mind. Only in the science schools did there seem evidence of attempts to assess higher cognitive level learning abilities. Strategies adopted by schools to improve performance seemed to focus on extra classes to prepare students for examinations. These were either conducted a few weeks before the examination, or took the form of special projects aimed at improving overall understanding and achievement in science. In the science schools, apart from conducting remedial and enrichment classes, teachers were also involved in counselling and trying to motivate students towards better achievement, though this was not confined to science alone.

4.2.4 Some emerging issues

In conclusion, a number of issues arise from this overview that have implications for the rest of the study. First, and perhaps most importantly, both the survey and case study data suggests that access, provision and performance is more problematic in rural than in urban schools. It also appears that on some indicators the situation may be deteriorating.

Second, data on selection, transition and enrolments, and transfers between streams convincingly demonstrates that participation in Form IV science has been declining in the survey and case study schools with a particularly sharp decline recently. The selection system has been changed as of 1992 so that arts and science streams will no longer have the separate identities that they have had up to now. Whether this will reverse trends in participation in science will depend on how the new system works in practice.

Third, a growing number of schools, especially in rural areas have only one class of science and are experiencing declining enrolments. If this continues fewer will be able to offer single science subjects in the future.

Fourth, though most science is taught by qualified teachers, a significant amount in some schools is not. This issue is amplified in later chapters. The survey draws attention to the fact that graduate science teachers represent about 50 per cent of all science teachers but are concentrated in urban schools and in the higher Forms. Some case study schools deploy science teachers in ways which mean that not all science is taught by those trained in science and the distribution of science-trained teachers between schools appears uneven.

Fifth, the proportion of principals with science qualifications is very low. Moreover, in 5 of the 7 rural schools visited in the case studies principals were away or had not been replaced. Both these circumstances may have an effect on science teachers' morale and the support they can call on.

Chapter 5

Insights into science education 1: why are enrolments falling and how is science taught?

This chapter reviews evidence from all parts of the research to provide a more detailed discussion of two sets of issues. The first is concerned with the problem of falling science enrolments, the second with common patterns of teaching and learning.

5.1. Falling science enrolments

Earlier analysis establishes unambiguously that there has been both a relative and absolute decline in the number of students taking science at Form IV. Under the old curriculum selection for Form IV was dependent upon performance of students in the SRP examination. Selection for science in turn, depended upon overall performance and specifically performance in Science and Mathematics. While overall transition into Form IV has remained in the region of 66 per cent for the period 1985 - 1990, transition into science has decreased from 20 per cent to 15 per cent and that into arts has increased from 42 per cent to 46 per cent. Provisional figures suggest that for 1991 the transition into Form IV science may have fallen to about 12 per cent of the enrolment in Form III of the previous year.

The data also indicates a bigger decline for boys (8 per cent) from 1985 to 1991 than girls (6 per cent) though this appears to be linked to the fact the overall transition into Form IV for boys has decreased in the period by 2 per cent compared to a corresponding increase for girls of 3 per cent. For urban schools the transition rate into Form IV science averaged 24 per cent compared to 9 per cent for rural schools. Moreover, high scoring urban schools had a transition rate of 28 per cent into science compared to low scoring rural schools with a transition rate of only 5 per cent in the survey sample. In all but one case study school (School 2) less than half of the students who passed the SRP examination qualified to do science. The percentage who qualify has been decreasing or remained stable and in no case increased. In some of the case study schools it was between 5 per cent and 10 per cent. Box 5.1 illustrates three typical cases from the case study schools.

Box 5.1. Declining selection into science (Schools 2, 9 and 12)

> School 9 is a rural school with SRP performance above the state mean. The percentage of students who qualify to do Pure Science is relatively high but the trend has been downwards. In 1988, 31 per cent of SRP students qualified to do science. The figure dropped to 25 per cent in 1989 and 23 per cent in 1991.
> School 12 is also a rural school with performance above the state mean. Selection for science has been relatively low and is declining. The figure was 17 per cent in 1989 and dropped to 6 per cent in 1990.
> School 2 is located in an urban area. Forty-eight per cent qualified for science in 1988. Data for 1989 was not available but 1990 figures indicate a decline to 39 per cent.

The decreasing proportion of students who qualify to do science at Form IV level can be attributed to two main factors. Firstly, the entrance requirements for Form IV science has generally required that a Credit 6 or better in Integrated Science and Mathematics is obtained. In the case of Integrated/KBSM Science the proportion of students obtaining at least credits dropped from 40 per cent in 1986 to 35 per cent in 1990. This will have reduced the proportion of students who qualify for science. The decreasing numbers can also be attributed to stricter entry requirements for selection for Form IV science. In the case study schools SRP students with an aggregate of 22 or 23 points across five subjects could qualify to do science before 1990.

In 1990, the cut-off aggregate applied was 15. This made it more difficult to enter the science stream. In the survey schools which provided data the number of students offered science places dropped by 27 per cent from 2,218 in 1989 to 1,619 by 1991. The decrease was larger in rural schools (14 per cent) as compared to urban schools (10 per cent).

In addition to the two reasons cited above, significant numbers of students offered places in science have been applying for transfers to the arts stream. About 15 per cent of science-qualified students applied for transfers in 1990 in the survey schools. Interviews in the case study schools suggested that transfer requests arise for at least three reasons:

(i) The perceived greater rewards for jbs in other areas, e.g. accountancy, economics;
(ii) The perception that science is a difficult subject to study and do well in;
(iii) Lack of motivation and interest in studying science as a result of perceived irrelevance.

Some other reasons given for opting out of Science are illustrated in *Box 5.2*.

Both case study and survey data show that opting out of science is most prevalent in urban areas. Teachers in the case study schools indicated that the number of students who wanted to opt out of science could actually be larger than that indicated by the number of formal requests. In their schools between 30 per cent and 50 per cent of requests for transfer were successful. Many of the rest who asked for transfers informally were discouraged from formally applying. This probably explains why in the survey a large proportion of formal requests for transfer were granted – many others were discouraged before they became formal requests. Teachers interviewed felt that students who wished to transfer but were not allowed to, became 'resigned' to remaining in the science class although they did not like science or found it difficult to study.

With the introduction of the KBSM at upper secondary level, the streaming system has been changed such that allocation decisions on the subjects studied are made at school level. Thus conditions for entry to science subjects can be expected to vary between schools. There appears to be no standard guidance in the case study schools on how the selection should be made. Principals of the case study schools indicated that option choices in their schools will be dependent mainly upon the availability of facilities and teachers.

Box 5.2 Opting out of science: some reasons (Schools 9 and 13)

Interviews with science teachers and the school counsellor in School 1 revealed a number of reasons as to why students asked for transfer. All but one teacher cited a lack of confidence in performing well in science subjects (especially Physics) and a lack of interest in science subjects as the main reasons for change.

Group interviews held with 10 students who requested transfers to the Arts revealed that the majority of them felt that their poor performance in the subject would handicap them. Many regard science, especially Physics as difficult and uninteresting. A few students cited a lack of reference materials while many cited learning problems in mathematics as a deterring factor.

School 13 is a science residential school. The first social science class was started in 1986 when students with 'weak' results in science and mathematics were persuaded to take Principals of Accounts and Science as well as Additional Mathematics. While the initial response was less than enthusiastic, the demand for Social Sciences classes gradually grew due to the belief by parents and students that job opportunities were better in this field. Scholarships offered by the Public Services Department for further studies in Accountancy and Business Administration further strengthened this belief. Today the demand for places in Social Science has increased to the extent that an additional Social Science class had to be opened at Form IV level while the number of Science classes has been reduced from 5 to 4.

The prevalent feeling among principals and teachers is that with free option choice under the KBSM there will be a decrease in the actual number of students wishing to take science-based electives. This is likely to be especially so in urban areas. Case study data indicates that the choice of science electives in order of decreasing popularity is thought to be Biology, Chemistry and Physics. Physics is the least popular science among girls and is perceived as the most difficult by most students. It also seems possible that more science students will do Principles of Accounts along with two pure science subjects.

Rural children still find science prestigious and are generally more reluctant to transfer out of science. However, they face several obstacles in continuing to study science. Rural school students' chances of studying science are reduced by their relatively poor performance in mathematics. In addition, as there are fewer schools offering pure science in Form IV in rural areas this in itself is a constraint for some students. Although the best students may be admitted to residential schools and town schools with hostel facilities (e.g. Rancangan Khas schools) there are still a significant number who could study science but are prevented from doing so by the preferences of parents and students not to travel long distances. An example is provided below.

Nationally, science stream students in Lower VI in 1990 were about 18 per cent of those in the pure science stream in Form V in 1989, and about 5 per cent of total Form V enrolment in 1989. About 28 per cent of Lower VI enrolment is in Lower VI science. The corresponding figure for Upper VI science is 24 per cent. The difference can be explained by drop-out and transfer of students to other courses. As with upper secondary science stream enrolment there has been a decline in the number of students doing science at sixth form level from 18,729 in 1987 to 14,884 in 1991 (provisional). Figures for 1991 are approximately equal to those for 1983. The desire to opt out of science at Form VI level was common in both rural and urban schools, whether with performances below or above the mean. A case in point is illustrated below.

Box 5.3 Distance - a deterrent factor for rural students (School 1)

In School 1, of the 11 students selected for science only 2 remained. The others had opted for other streams for a number of reasons, the major one being problems related to transport and accommodation since the school with science classes was about 25 km away from their homes and buses were not frequent. One of the students, a girl with an aggregate of 11 units in the SRP, had to leave home for school two hours before school each day, one hour on the bicycle and another by bus. Coming home from school involved having to wait an hour or more for buses due to the infrequent service. She opted out of the Science class after a term.

As in the case of upper secondary enrolment, students in urban schools form a large percentage (63.0 per cent) of total enrolment at Form VI level. There are more males (65 per cent) than females and the disparity is greater in rural compared to urban areas (80:20 compared to 56:44). Science students at this level usually take all the 3 Pure Science subjects. Preference to take Principles of Accounts and/or Economics and substitute these for science seems general in several of the case study schools. Some principals have reacted by supporting transfer to the Arts Stream while some have accommodated this demand by opening science classes with these options. The case of one school is illustrated below.

Box 5.4 Drop-out from science at Form VI level

In school 9, the 'drop-out' rate from Lower VI Science (to Arts) can be gleaned from data on enrolment for 1989 and 1990 for School 9. In 1989, 77 students were selected to do science in the school. Of these 20 per cent applied for transfer to the arts, of whom 60 per cent were successful. June 1989, only 38 students were enrolled in the science class. In 1990, the number selected to do science increased to over 100. However, 25 per cent asked for transfer and 23 per cent were successful. By June 1990, enrolment in the science stream had dropped to 33.

The problem of falling enrolments in science is therefore complex. It is the result of a number of factors that interact and discourage many of those qualified for science from studying it at higher levels. It is also partly due to attempts to improve the quality of Form IV science entrants by raising admission criteria, though these have now been relaxed again so that a minimum of Credit 6 at SRP is required. Mixing science with more popular subjects (principals of accounts, economics) does appear to have helped retain some students in the science stream and KBSM provides more flexibility to do this. The paradox whereby science remains relatively popular in rural schools, but more difficult to study, is difficult to resolve but clearly a cause for concern.

Box 5.5 Declining participation in sixth form science (School 2)

School 2 is a school that has been traditionally strong in science. Originally all classes at sixth form level were science classes. Beginning from 1983, a new system was introduced and students opted to offer arts subjects for the STPM examination. In 1983, 19 students sat for the Economics paper on their own. In 1984, 50 offered Economics and 4 offered principals of Accounts. By 1985, the figures had increased to 63 for Economics and 15 for Principal of Accounts. The increasing tendency for students to offer arts subjects led to these subjects being incorporated in the time-table as soon as the school managed to obtain qualified teachers for them. The Senior Assistant attributed this to the increasing number of girls being admitted to Form VI and their tendency to opt for arts-based subjects which are said to be easier and prepare better for employment. This is supported by enrolment data. In 1986, of the 145 girls in sixth form 74 per cent were in the science stream. By 1990, there were 182 girls in sixth form of which only 31 per cent were in the science stream. Correspondingly, from 1983 to 1990 the number of boys in sixth form dropped by 28 per cent from 177 to 127. This drop was attributed to the requirement of a credit for Bahasa Melayu in the SPM which the Senior Assistant felt was a problem for the boys.

5.2. How is science taught?

This section is concerned with how science is taught to different students and explores the educational environment in which teaching and learning takes place. It has several parts. First, it presents evidence on the aims and purposes of science as seen by different actors – principals, teachers and students. Second, it discusses the patterns of practical work which science teachers organise and comments on the relationships between these and the achievement of curriculum objectives. Third, the forms of use of teachers' guides and materials for students are reviewed. Fourth, the quantity and quality of students' work is considered in class and for homework. Fifth, variations in teaching methods in different schools and for different groups of students are described. Sixth, opportunities for providing science education outside the classroom are noted and the frequency with which they take place is considered.

5.2.1 Aims of science education

All the science curricula include statements of aims and objectives which are intended to define the framework within which teaching and learning takes place. It is important to explore the aims and objectives that teachers have for the teaching of science. How they teach will depend on the extent to which teachers are actively aware of the curriculum aims and objectives and the extent to which they are committed to them as important goals.

Interviews with teachers in case study schools revealed that many teachers still conceived of science curricula as primarily defined by scientific facts and the content of different topics. The weight of opinion in interviews concerning the purpose of teaching science was most frequently in terms providing scientific information and few stressed the development of intellectual skills amongst their students without being prompted. Most of the teachers interviewed regarded the teaching of science as important because it gave students knowledge of the human world and of nature. This was frequently used to justify why it should be taught to all students. Most teachers also felt that there should be no differences in the science taught to urban or rural students though they acknowledged that high and low ability students should study science to different depths. However, most seemed unable to articulate what these differences in depth should amount to. It often seemed that depth was interpreted in terms of more 'knowledge giving' to higher ability students rather than the development of more complex intellectual skills. Very few teachers were able to articulate clearly a wider range of general aims for science education, e.g. developing scientific enquiry methods, logical thinking strategies, and problem-solving skills. This was despite the fact that all the science curricula emphasise the acquisition of scientific and manipulative skills as an essential complement to scientific knowledge.

These dominant knowledge-based views of science education and its objectives appeared to be consistent with styles of teaching observed in case study schools. Lessons observed were generally didactically presented and were teacher-centred with little input from students. Typically lessons started with a discussion of previous work which was followed by instructions for a practical activity or a demonstration which was then written up. Students in most cases played a passive role listening, following instructions, or copying out accounts from the blackboard.

Although teachers used the question and answer techniques in class, questions tended to be confined to lower cognitive levels, mostly involving the recall of information rather than requiring reasoning and interpretation. There seemed to be real problems in the discovery-inquiry approach advocated by the curriculum both at lower and upper secondary levels. Observations of teaching provided few examples of what seemed to be guided discovery. The Senior Science Teachers in three of the schools also felt that the approach was more suitable for high ability students and did not work as well with average and below average students.

There were some exceptions. These were mainly found in the residential schools where it was more frequent for students to be asked questions and take part in discussing how to do experiments and interpreting the results. Teachers who did this noted that it was more time consuming than 'chalk and talk' and that a lot of effort had to be invested in preparing lessons and thinking about questioning strategies to lead students through a scientific reasoning process.

The 'conveying information' approach emphasised by many teachers was consistent with views held on public examinations which were generally felt to devalue scientific thinking skills. A teacher in School 2 claimed that 'while the science syllabus advocates learning by enquiry the examinations give emphasis to the knowledge component of science'. This reasoning was used by many teachers to explain why they chose to stress factual knowledge since this, they felt, was what the examinations predominantly tested. A typical view was expressed by a senior science teacher in school 3 who said that 'even if students do not understand concepts they can get by the examination by merely memorising facts'. Thus examinations appeared to be a major motivating factor for the teaching and learning of science in most of the schools. In Schools 2, 6 and 13, all of which were high performance schools, and the latter two residential, teachers were well versed as to the types of examination questions to be expected. During lessons they made special mention of important examination pointers. Teachers appeared to be at a loss when asked about how to motivate students who were not moved by the desire to perform well in examinations. This was illustrated by a teacher in School 4, a low performance school. She had previously taught in a residential school and was dissatisfied with her present students who were 'not interested in passing the examination, whereas in my previous school

I was able to raise a lot of enthusiasm simply by mentioning that a certain topic was frequently tested in the examination'.

5.2.2 Practical work and the experimental method in science education

All the current science curricula place a great deal of emphasis on the value of practical work and developing familiarity with experimental methods amongst students. This is reflected in the amount of time devoted to practical work. Under the new curriculum at lower secondary level, and the old curriculum at upper secondary level, 4 out of 5 periods (80 per cent) are designated as laboratory periods to enable practical work to take place. Generally, there appears to be little difference in the frequency with which science teaching takes place in laboratories between urban and rural schools. In survey schools about 72 per cent of science teachers in rural schools and 79 per cent of science teachers in urban schools reported using the laboratory more than 75 per cent of the time in the 2 weeks prior to the survey. Somewhat paradoxically there appears to be some disparity in the frequency of use of the laboratories between high, medium and low performance schools. In high performance schools 62 per cent of the teachers reported use of the laboratory exceeding 75 per cent of the time; the corresponding figures for low and medium performing schools were 79 per cent and 78 per cent respectively. This higher utilisation is probably related to the greater pressures on space and class size in high scoring schools, most of which are double shift schools in urban areas as noted previously.

This finding has to be seen alongside the common belief among teachers that involvement in practical activity does not necessarily enhance performance in examinations. A teacher in School 2, a high performance school explained, that 'it is possible to get by without practical activity as examination questions rarely give prominence to practical experience'. At SPM the practical examination for the pure sciences only accounts for 10 per cent of the total marks of the examination and this contributes to the lack of importance placed on practicals. Since there are no practical examinations for KBSM or Science the incentive to undertake much practical work is limited. Thus although the survey indicates a high level of use of laboratories for conducting lessons, this does not reflect the actual amount of practical activity carried out. Although 77 per cent of teachers surveyed reported conducting lessons in the laboratory for more than 75 per cent of the time available only 35 per cent of them reported conducting class practical activities in more than 75 per cent of the lessons in the same period. This suggests that a lot of science teaching in laboratories is not characterised by practical activity. Further evidence of this was obtained from the case study where it was noted that very often lessons conducted in the laboratory were theory lessons. Thus in School 3, a Physics teacher was observed spending the entire 80 minutes of the lesson lecturing and in School 4 a KBSM teacher spent a whole double period talking about the various classes of food and giving notes on the topic without any practical activity involved.

In interviews most teachers appeared to be strongly supportive of practical activity though their practice did not seem to match their enthusiasm in discussion. There was evidence from the case studies that there were disparities in the amount of practical work that was conducted in different subjects. Student exercise books were analyzed and indicated that among the pure science subjects the least practical activity was often in Biology. The amount of practical activity for General Science was minimal and this was noted in both high and low performance schools. Practical activity for KBSM Science appeared to be as frequent as that for Physics and Chemistry in upper secondary.

A fairly typical finding is illustrated by School 7 where there appeared to be only 3 practicals for Biology from December up to the time of the case study visit in July. Although a practical exercise book was used for General Science in the same school it was seen to consist almost entirely of teacher-given notes and there was no evidence of practical activity. In School 2 a General Science teacher noted that he was the only teacher of the subject who did practicals. For General Science the situation is further aggravated by the fact that not all case study schools allocated 4 laboratory periods to the subject. In School 13 for instance no specific laboratory periods were allotted and the teacher concerned could only use the laboratories if they were free. This picture of the lack of Science practical work was reinforced by survey data.

Generally, teachers favoured conducting practical activity in groups. Of the teachers surveyed 54 per cent reported group sizes of 4-5 students per group. Direct observation of classes noted a range of 1 to 7 students per group. Generally, smaller group sizes were associated with science classes in the rural areas which had smaller class enrolments. Thus in

School 10, a rural school, practicals were done individually for Form V Science (enrolment 14) and in pairs for Form IV Science (enrolment 11). In the same school group sizes for KBSM Science and General Science were 4-6 and 6-7 respectively. In contrast in School 2, an urban school, four groups of approximately 10 students were the norm for classes which had enrolments exceeding 40 students per class. The data indicate that group sizes were smaller for pure science classes and this was true for urban and rural, as well as high and low performing schools.

Teachers interviewed appeared to favour group activity, rather than individual work, since there was less preparation and washing up needed and it was easier to maintain discipline and control among students. However most appeared not to be sensitive to the fact that large group sizes limited pupil participation to 2-3 students per group, leaving the others as passive onlookers. A typical case is illustrated below.

In the case study schools groups for practical activities were generally fixed in size and composition regardless of the type of experiment conducted. In mixed sex schools, groups were always composed of either boys or girls. Generally, groups were formed at the beginning of each year according to the seating arrangement of students.

Box 5.6 Group practical activity in science (School 2)

> In a practical lesson conducted in School 2 students were required to test the pH of several given substances. The experiment required very simple apparatus consisting only of test tubes and pH paper, yet it was done in groups of 5 resulting in only 2 students being involved in the testing of each substance. Although the teacher did attempt to ensure that each substance was tested by a different pair of students, this did not appear to work and ultimately the same students were involved over and over again. Other students were observed to be occupying themselves by copying what was on the blackboard, chatting among themselves or merely passively observing the experiment.

Teachers across the 13 case study schools noted distinct differences between girls and boys with respect to practicals. Boys were considered to be more confident, innovative and persevering, girls more careful but less exploratory. Practical lessons observed generally followed a similar pattern. They began with a review of related knowledge and facts and an explanation of the aims of the experiment. This was followed by instructions on the procedure to be followed and the observations and readings to be carried out. Students then conducted the experiment in groups. The practical lesson generally ended with a discussion on the practical. Most teachers appeared to be adept at organizing practicals and instructing pupils on procedures and observations to be made. However, there were several areas in which teachers appeared to have problems:

(i) While many teachers mentioned the aim to students prior to the start of an experiment this was usually simply repetition of aims and objectives as stated in textbooks. Seldom was there an attempt to translate formal aims into something meaningful for students that related to their world of experience. Thus often students appeared to be going about the experiment with only a vague idea of the purpose of the experiment. A typical example was found in School 7.

Box 5.7 Discussion of the aims of practical activity (School 7)

In School 7 an experiment was conducted in which students were required to investigate how water enables acids and alkalis to exhibit their specific properties. To do this students were required to do a litmus paper test on the aqueous and non-aqueous forms of benzoic acid as well as on benzoic acid dissolved in toluene. The same steps were to be repeated with sodium hydroxide. At the beginning of the experiment the teacher merely mentioned that the experiment was aimed at investigating the role played by water. Despite the fact that the experiment was conducted in several parts, no attempt was made to link the various parts in the discussion of the aims. As a result, students were observed to be going about the practical activity mechanically without understanding the relationship between the various parts of the experiment.

(ii) Although teachers were able to help students acquire manipulative skills in handling apparatus, making observations, and recording data they seemed less able to encourage students to acquire higher order intellectual skills, e.g. interpreting data, hypothesising, making generalizations. This was reflected in the infrequency of meaningful discussions based around practical activity. More often than not, discussions were merely a comparison of observations and experimental results between groups. After this the teacher generally read out to the students the anticipated conclusion of the experiment which students copied into their books. There was rarely a discussion of why results might differ between groups.

(iii) Teachers observed were often not adept at coping with experiments that did not work well. In these cases the most common response was to merely provide students with the 'correct' answers or ask them to join a group which had managed to obtain the 'correct' answers. This is illustrated by a lesson in School 13.

Box 5.8 Experiments that do not work (School 13)

In a lesson in School 13 involving Form II students, several groups had trouble with an experiment on the neutralization of acids and alkalis using the titration method. The experiment required that students perform the titration slowly so as not to overshoot the point of neutralization. Many had trouble partly because that titration was performed too fast and partly also due to faulty burettes provided. The teacher however was not sensitive to this and instead of explaining what had gone wrong merely asked students to join another group for whom the experiment 'worked well'.

(iv) In several schools (Schools 4, 7 and 8 which are all low scoring) teachers felt that students faced considerable difficulties in following procedural instructions in laboratory work and much time had to be spent clarifying these before students could conduct practical work.

(v) Teacher incompetency was cited as a contributory factor in causing difficulties by some senior science teachers. This included criticisms of teachers teaching subjects they had not been trained in, inadequate teacher training courses, and lack of in-service training for self improvement. In six schools difficulties were explicitly mentioned in teaching the Physics-related elements of General Science especially where teachers had little physics background. This made it very difficult for them to organise practical work and they struggled with the theory parts.

Thus practical investigations appear prominently in most science classrooms (with the exception of General Science) but the evidence seems to indicate that while some manipulative skills and knowledge of the results of experiments are acquired intellectual skills are often not stressed. An overall impression from observation was that in many but not all schools science practicals were 'busy time' activities. During this 'busy-time' students appear to be gainfully occupied following step by step instructions, copying the method into their books, filling in the blanks in work books, etc. Almost all practical activity appear to be standard exercises taken either from textbooks or workbooks. There appeared to be few activities designed by teachers themselves or activities in which pupils were allowed to do independent project or experimental work. Teachers generally explained the lack of such activity by stating that they felt constrained by the syllabus. In addition, there was the general feeling that they had to complete all the experiments suggested in the textbook which left little time for other activities.

Clearly it is not the amount of activity which is important but the extent of meaningful learning derived from these activities. For effective learning to take place practical activities need to be complemented with skilful teaching that can help students acquire scientific reasoning skills and produce a sense of excitement and continuing enthusiasm for science. The case studies provided few examples of opportunities to acquire such skills through practical work.

5.2.3 Use of textbooks, workbooks and teachers' guides in teaching

There are differences between urban and rural teachers in their perception of the usefulness of textbooks. About a fifth (23 per cent) of urban science teachers indicated in the survey that the textbooks were not useful whereas only 10 per cent of rural teachers responded in this way. Rural teachers probably use textbooks more frequently than urban teachers and have fewer alternative sources of teaching material. General science textbooks were judged least useful by rural teachers (37 per cent) and pure science textbooks by urban teachers (44 per cent). Lack of usefulness of textbooks was attributed to the fact that textbooks were outdated and were not sufficiently orientated to the demands of examinations. The senior science teacher of School 13, a science residential school, however, felt that whilst the lack of examination orientation might be an important reason for the lack of use of textbooks, a more important reason was that even some of his teachers could not answer some of the questions posed in textbooks. In both urban and rural schools, a very small percentage of KBSM science teachers did not find the textbooks useful but they are widely used. These are recently produced materials whereas the pure science books have not been updated for many years. Under KBSM new versions will be produced.

Commercially produced workbooks are widely used to substitute for the textbooks. The great majority of science teachers (95 per cent) perceive workbooks as useful and this is particularly so amongst General Science teachers. The survey indicated further that the highest percentage of those who found workbooks useful were General Science teachers (100 per cent). Observations suggested that usage was greatest amongst pure science teachers and least for KBSM teachers. Workbooks were seen as convenient and time saving since they concentrated on the main points for each topic. They also provided examples of previous years' examination questions to be used for practice.

At lower secondary level students frequently keep practical record books in which they are required to write out reports of practicals. Teachers interviewed indicated that they found it difficult to teach the mechanics of report writing and the majority resorted to writing out the entire report on the board leaving blanks for students to fill in. In 2 schools (Schools 2 and 4) teachers had resorted to workbooks to overcome this problem which provided written up accounts. Though observation indicated low usage of workbooks at lower secondary level, survey data suggested use might be more common when observers were not present. Workbooks are convenient in that most of the report is pre-written and students merely have to fill in their observations and readings. Many teachers complained that were too many experiments to be conducted in the time available. Using workbooks enables results of experiments to be written in without conducting some experiments.

The survey of teachers indicates that only 4 per cent of teachers did not find teachers' guides useful. However, observation in case study schools revealed that these books were seldom used by teachers who preferred to use commercially published revision books. Interviews with teachers confirmed that revision books formed the most important and frequently used reference books. In School 3, the only difference in the reference books used by teachers and students was that teachers generally had access to more than one revision book while students referred to only one revision book.

Student books were reviewed in all the case study schools. In most cases these contained teacher-given notes although in three cases (Schools 13, 7 and 10) there had been attempts on the part of teachers to get students to make their own notes. However, in both schools 7 and 10 (both low performance and rural) the notes were incomplete.

5.2.4 More on teaching strategies

In most of the schools surveyed there was a consensus in favour of streaming more and less able students into different groups. School principals generally felt that pupils of similar ability levels benefitted from being grouped together – about 70 per cent were of this opinion both for more and less able students. Streaming by ability was common in the case study schools though it must be remembered that streaming is usually done by 'general ability' and not for specific subjects such as science. In one of the case study schools there had been an attempt by the administration to abandon streaming by general ability at the lower secondary level.

Box 5.9 Limited streaming (School 2)

In School 2, in an attempt to ease discipline problems which arose as a result of low ability students being grouped together, the administration decided to experiment with 'limited streaming'. Here the best students were put into 2 classes and the rest were randomly allocated to classes. The administration also felt that the move would help reduce the problem of teachers being reluctant to teach the weaker classes. The move appeared to be successful in that the administration noted fewer disciplinary problems among students. Also it appeared to be helpful for teachers who experienced problems in class control. The senior assistant also commented that while previously some teachers expressed dissatisfaction at having to teach the less able classes, this appeared to have been reduced with the new system. The new system was, however, not appreciated by several science teachers in the school who felt that mixed ability groups were more difficult to teach and manage.

Interviews with teachers indicated that teaching strategies for less able students generally consisted of teaching at a slower pace, leaving out the more difficult topics, and giving more detailed notes. Teachers seldom seemed to have an idea of why students found particular topics difficult to grasp. For example electricity was noted to be a difficult area by most teachers. However, most attributed the difficulty to the fact that the topic had a high mathematical content. Teachers did not seem to be aware that there were likely to be conceptual problems with the topic as well which might explain why it was seen as more difficult than other topics that required some simple calculations. Difficulties with topics were often attributed to general factors such as lack of interest, low mathematical competence and abstractness and few could explain the nature of students' problems from a cognitive point of view. High ability students were not obviously favoured with more challenging teaching methods. In school 7 which had 'Rancangan Khas' classes these merely represented a grouping of better ability students. The students were not involved in any extra project work or enrichment exercises despite the fact that the teacher noted that he could cover topics in a shorter time and that the students were quicker to learn than non-Rancangan Khas students. Similarly, the science residential school visited did not seem to enhance its science teaching and the emphasis was strongly on performance in examinations.

Most of the teachers interviewed at lower secondary level commented on the lack of time to complete all the experiments specified in the text and complained of having to rush through them. One teacher in School 7 tried to solve the problem using the 'station approach' in practicals. This is described below.

Box 5.10 The Station approach (School 7)

In the 'station approach' related practical activities were grouped together. Students were required to go from one activity to another during the double period after which the teacher would discuss the related activities together. The teacher admitted, however, that it was difficult for him to keep this up as it required a great deal of preparation on his part and he found it difficult to approach other teachers for help.

This approach was unique in the case study schools where most teaching followed closely similar patterns as already described. Survey data suggests that teachers in rural areas feel it is more difficult to introduce new teaching methods than teachers in urban schools, but our observations detected little difference in teaching styles between the two groups of schools.

Time constraints and the pressures of completing the syllabus and preparing students for examinations were used by teachers as a justification for why little science activity took place outside normal classroom teaching. Science societies existed in 7 of the 13 case study schools but all 7 were inactive. This was true even in the science residential school. The senior science teacher of the science residential school commented that most teachers did not value science club activities as a complement to their classroom teaching and saw them as a burden which would contribute little to examination performance. Where activities had been organised in the past they seemed to be confined to the organization of quizzes and the making of teaching aids. Science-based school visits were not organised by any of the schools. Library use was also not an integral part of teaching and learning. While a teacher in School 4 acknowledged that library research could be an important tool in the study of science she was quick to point out that this strategy required that students be exposed to library research skills. A teacher in School 2 commented that although the KBSM provided opportunities for the use of the library a major problem was that the majority of the books were in English and students could not read them.

5.2.5 Teaching and learning difficulties

The topics and activities that students found difficult were explored both in the survey and in the case studies. In a student questionnaire issued in case study schools students were asked the extent to which they felt understanding theory, performing calculations, note- taking, performing project work and performing experiments posed difficulties for them. The response pattern indicated that there was a difference between Form II and Form IV students in the case study schools. While Form IV students found most difficulty in understanding theory and doing calculations, Form II students experienced greater difficulty in performing experiments and doing project work. It is interesting to note that the two areas which were least problematic (calculation and understanding theory) at lower secondary level, became the most problematic areas in learning science at upper secondary level. Both arts and science, as well as rural and urban students in Form IV, indicated the same areas of difficulty. Doing experiments and taking notes appear to be the least difficult tasks. Other evidence from the case study schools showed that note-taking was usually a copying exercise, not a creative one. Also much practical work seemed to require few reasoning skills and much following instructions. This may explain why these activities were perceived as relatively easy.

The same group of students were also asked who they approached for help when faced with learning difficulties. All groups – rural or urban, lower or upper secondary, arts or science – said that the majority (58 per cent – 85 per cent) of them referred to books. Next to referring to books, Form IV students sought the help of teachers and friends when faced with problems in learning science. Form II students seemed to rely more on their teachers compared to Form IV students. At Form II level, more rural than urban students sought the help of teachers suggesting they may be more dependent on the teacher than other sources of information. Students rarely seek the help of members of their own family (parents and siblings) when they have difficulties in learning science.

Two interesting observations can be made from the above analysis. While most of the students rely on books to help them solve problems in learning science, the majority of school libraries and resource centres are not well-stocked with science reference books, especially those written in Bahasa Melayu. In addition, Form IV students and teachers in the case study schools rarely seemed to refer to the textbooks provided, rather they depended on workbooks. It is also interesting to note that understanding theoretical concepts and calculations which is the problem faced by most Form IV students did not appear as a significant problem at all at the lower secondary school level. This may reflect the relative absence of these tasks in the teaching of Science at this level.

The data on students also indicated several significant differences between various groups of students studying science which could possibly have affected their performance in science. Form IV science students expressed greater interest in science compared to Form IV arts students. Female students also appeared to feel that science is a difficult subject. Analysis of the areas of difficulty indicated that female students experienced greater difficulty in the application of formulae while for male students the difficulty was in questions requiring explanations. There also appeared to be a significant difference between rural and urban students with respect to the perception of the importance of science for entry into the job market with the former attaching greater importance to it. This is supported by findings from the case study.

Attempts were also made to find out which amongst the science subjects was considered the most difficult by Form IV students. Students ranked Physics as the most difficult with Chemistry not far behind. Biology was regarded as difficult by much smaller proportions of students. The pattern was similar for both male and female students. When teachers were asked which subjects their students found most difficult the pattern yielded a strong consensus that Physics was most difficult (*see Table 5.1*). Most teachers perceived Physics to be the most difficult subject in science for the majority of both boys and girls in the science stream. Of the teachers teaching science 40 per cent perceived Physics as the most difficult for boys and 79 per cent for girls.

Interviews with science teachers in the case study schools revealed that the difficult topics in Physics at the upper secondary level include energy, force, motion, electrons, transistors and cathodes rays, electricity, heat, circular motion and waves. This seems to be due to the fact that most of the concepts involved are abstract and complex and also because most involve calculations. Topics in Chemistry considered difficult include atomic and molecular structure, molarity, balancing chemical equations, reversible reactions, electrolysis and energy, most of which involved calculation and also have abstract conceptualisations. Biology teachers found topics such as the relationship between volume and surface area in animals, ecology-based topics, growth, reproduction and genetics, water and body fluids, the heart, enzymatic reactions, nervous system and the skeleton difficult. The reasons given ranged from limited choice of experiments to the problem of safety on field trips.

Teachers were asked to identify difficult topics for students. *Table 5.1* shows topics that were identified by more than 20 per cent of the teachers who responded.

Table 5.1. Perceptions of teachers in urban and rural schools of topics considered difficult for students by subject

Subject	Topics	% of Teachers who perceived topic as difficult	
		Urban schools teachers	Rural schools teachers
KBSM Sc.	Electricity and electromagnetism		
	Force and motion	29.8	27.1
	Earth and the universe	28.5	19.9
		24.8	41.7
Gen .Sc.	Atoms and the structure of matter		
	Electricity and energy	19.1	22.2
	Production and transfer of	46.8	28.9
	Electrical energy		
	Electrolysis and chemical reactions	36.4	26.2
	Movement (motion)		
	Communications	25.6	25.6
		23.3	16.3
		27.9	41.9
Physics	Force and motion	22.9	23.0
	Electromagnetism and alternating		
	Currents	66.7	6.2
	Space travel, satellite and planets	24.2	24.6
	Vibrations and waves		
	electrons	27.3	20.1
		33.3	33.8
Chemistry	Atoms and chemistry	69.2	61.4
	Electricity and chemicals	23.1	20.0
	Oxidation and reduction	28.2	20.0
	Reversible reactions and	30.6	27.1
	equilibrium	36.1	35.7
	Carbon compounds		
Biology	Size, surface area, shape, support		
	and movement	40.0	34.8
	Interrelationships between living		
	organisms and their environment		
	Micro biology	8.6	23.2
	Water and body fluids	30.3	11.5
	Growth, reproduction and	27.2	22.7
	differentiation		
	Identifying vhanges in the	39.4	28.8
	mvironment		
		33.3	40.0

An important implication of the analysis of difficult tasks and subjects/topics relates to science teaching methods and strategies acquired in teacher training colleges and universities. As students find difficulty in understanding abstract topics and those requiring calculation, teaching strategies should attempt to make these topics more easily understood. Of particular importance is the teaching of Physics, a subject which many students perceive as being difficult. Rural teachers perceive that students enjoy practicals, and in view of the relatively poorer performance of rural students it may be useful to conduct practicals more often, and in smaller groups. It may also be necessary to develop different teaching strategies for the teaching of science in rural as compared to urban areas and for girls as compared to boys.

Data on the perception of students of science helps shed further light on how much science is learned or more precisely, who learns more science. It was found that Form IV science students are more interested in science, find science less difficult, have more practical work and feel they benefit from practical activity. They like science more, and feel that homework given is sufficient. Students following General Science in the arts stream, however, seem to think otherwise. Arts students indicated that facilities for studying science were more inadequate. Also they had difficulties in understanding the applications of science and seeing its usefulness. They were, however, more likely to perceive the notes given by teachers as being good and useful than science stream students. All these results are based on responses to attitude items and were significant at the 5 per cent level or better.

Further insight into how much science students learn can be gained from the type of questions set in internal school examinations, and the regularity of test and homework given. Data from the teacher survey indicates that the majority of teachers (78 per cent) gave monthly tests, most of which consisted of multiple choice and structured questions. There was hardly any practical testing and very little emphasis on essay-type questions. Most of the test questions were obtained from past year examination papers and revision books. These questions tend to be used in a summative way rather than diagnostically. In addition, multiple choice questions were thought to have an element of chance and thus some of the marks obtained were felt not to reflect the actual amount of learning that had taken place. Such questions, it was argued by some teachers, did not encourage students to develop skills in organising and presenting ideas and in reasoning. Remedial teaching based on results seemed infrequent except in School 13 a Science Residential School, where teachers were required to do a simple analysis on performance in school examinations. Topics found to be difficult were thus identified for remedial work. In the MARA school also a rigorous and unique system of assessment was practised as explained *in Box 8.4*.

Box 5.11 Testing and assessment in a MARA residential school (School 6)

School 6 had a rigorous time-table for assessing the progress and performance of students. Sunday and Thursday afternoon were set aside for tests. These tests were administered after the teaching of each topic was over, and were over and above the daily quizzes done at the end of a sub-topic. Apart from these, students also had semester examinations. These together constituted the overall marks of the semester (Grade Point Average). The weightage of each component is as follows: quizzes (10 per cent), tests (30 per cent) and semester examinations (60 per cent). Together these forms of assessment were used to identify students who needed additional assistance and plan remedial measures. As an incentive, the names of the ten best students for each test were exhibited on the notice board. In addition, samples of good answers were also read out to the class.

5.2.6 Homework and the supervision of students books

The survey indicated that homework was an important feature of teachers' teaching strategies. The majority of teachers give homework about half the time they teach, and about half indicated that more than 75 per cent of students completed their work on time. The survey indicated little difference in the amount of homework given by teachers in rural and urban areas as well as between teachers in schools with different levels of performance. The case study visits, however, revealed that students in high performance schools appeared to have been given a considerably greater amount of work compared to those in low performance schools as evidenced by the amount of material in their exercise books. The type of homework was confined to the completion of practical reports and exercises taken from revision books. In a few cases students were also required to make their own notes. There were very few instances of work which required original thought, e.g. essay-type questions. High performance schools asked for a greater amount of work related to examination practice, e.g. completion of past years questions.

As might be expected the overall quality of student work in high performance schools was better. Students books in low performance schools were characterised by incomplete and untidy work. In both high and low performance schools students work frequently displayed identical answers especially for questions requiring explanations. Teachers attributed this to the copying culture prevalent among students but appeared unable or unwilling to discourage this. Observations of teaching suggested that the answers were often identical because they were given by the teachers. In most of the lessons observed students were noted to pencil in their answers first and complete them in ink later according to the answers given by teachers during the discussion period.

Box 5.12 Quality of supervision of student books (School 9)

Most of the books were not regularly marked. Some were not marked even once during the last month. This was true especially with regards to notebooks. All books were marked with a tick (✓) often at the end of every topic. Five out of the eight sets of books checked had on such comments as 'good', 'neat work', 'untidy and incomplete'. Comments which aimed at motivating student thinking in particular areas/topics of science were almost nonexistent. Only three out of eight sets had correct answers inserted by the teachers. Only one teacher was noted to have corrected spelling errors made by students. Incomplete work in one class was marked by a big question mark and no follow-up was undertaken to ensure it was completed.

There appeared to be little difference in the survey schools in the relative frequency of marking of students' work between schools in urban and rural areas or between high and low performance schools. Indeed, in the case study schools there was no difference in frequency of marking between the MARA and Residential Science schools and the others. Eighty-three per cent of teachers surveyed reported marking books at least twice in the 2 weeks prior to the survey. Case study data indicated a frequency of about once a month. However, the frequency of marking does not take into account differences in quality. Very often marking was confined to ticks and crosses and comments by teachers were brief and general in nature, e.g. 'work incomplete' and infrequently raised questions that needed further thought from students. The following example illustrates what happens in many schools.

5.3.7 Emerging issues

Declining numbers in the science stream have a number of causes. These interact in complex ways. They include the perception that science is more demanding than other subjects; the difficulty of mathematical elements of science; the belief that remunerative jobs are more available to arts graduates; the lack of perceived relevance to everyday life. Tightening of entry requirements for science in 1990 also had an effect though the criteria have now been relaxed to former levels.

The opportunities for rural students to study science have been diminishing except for the most able selected for special schools. This is especially so at Form IV level where retention rates in science are also problematic.

Combinations of science with other more popular subjects (principals of accounts, economics) may help arrest the decline in enrolments.

The style of science teaching in many schools does not appear to reflect the intentions of curriculum developers closely. Much science teaching is heavily knowledge-based, is examination-orientated and is unlikely to develop a full range of scientific thinking skills. Variations in style to account for different students' capabilities and backgrounds were not prominent.

Practical work falls short of providing opportunities for most students to develop skills in solving problems using scientific reasoning and experimental methods. Group sizes are often large, participation limited and follow up discussion focused on identifying the expected conclusions.

Textbooks are only widely used by KBSR teachers. Upper secondary students and teachers tend to rely on commercially produced workbooks directed towards key facts and examination performance. Students' work shows a high degree of similarity suggesting original contributions are not expected.

Difficulties with the science curriculum are concentrated on relatively small numbers of topics which are identified above. Improving the materials available and presentation of these could make a substantial impact on students' performance.

Chapter 6

Insights into science education 2: who teaches science and how many science teachers are needed?

This chapter explores the characteristics of teachers who are teaching science and develops projections to estimate future training needs. First, it considers the teaching experience, training, and subject preferences of teachers. Subsequent sections examine the teaching loads of science teachers, their motivation and their attitudes to teaching science. Second, current output of science teachers is described and a number of different scenarios are used to project future levels of demand to illustrate how the training system should respond.

6.1 Characteristics of teachers

6.1.1 Who teaches science?

Amongst the science teachers who completed our survey 44 per cent taught in rural schools and 56 per cent in urban schools. A large minority (43 per cent) are certificate-trained and the remainder graduates. Amongst rural teachers 45 per cent were local (i.e. originating from the district in which they were teaching). A further 30 per cent were from other districts in the same state and 26 per cent from other states (*see Table 6.1*). Among urban school science teachers, 36 per cent were local, 21 per cent came from other districts in the state and 43 per cent came from other states.

Table 6.1 Teachers teaching science by years of teaching experience, sex, location of school and place of origin

Location of school	Place of origin	Teaching experience										Total
		< 5 yr		6 - 10 yr		11 - 15 yr		16 - 20 yr		> 20 yr		
		M	F	M	F	M	F	M	F	M	F	
Local		10	21	20	24	28	15	5	1	11	2	137
Rural	Other											
Dist.		18	21	12	10	14	5	6	1	3	1	91
Other												
State		12	23	9	12	1	16	1	3	0	1	78
Local		5	14	8	16	16	22	17	7	20	14	139
Urban	Other											
Dist.		0	10	7	15	13	14	4	5	6	7	81
Other												
State		9	38	17	36	9	20	7	9	5	19	169
Total		54	127	73	113	81	92	40	26	45	44	695

There are more female (58 per cent) than male (42 per cent) science teachers in the sample in about the same ratio as in the case study schools. The male:female ratio was highest in the urban schools where it was 1:1.6. Female teachers tend to be less experienced with 35 per cent having teaching experience of 10 years or less compared to 18 per cent for male teachers. Over 74 per cent of science teachers have been teaching for more than five years.

The survey data confirms that overall the number of science teachers is currently sufficient. However the breakdown of these teachers by subject discipline reveals that there are shortages in some science disciplines (see *Table 6.2*). Four hundred and ninety-three (73 per cent) teachers teaching science have been trained as science teachers. Of them 27 per cent were trained in KBSM Science, 13 per cent in General Science, 14 per cent in Physics, 20 per cent in Chemistry and 26 per cent in Biology. The majority of the KBSM Science teachers (99 per cent) and General Science teachers (90 per cent) are college trained. Pure science (Physics, Chemistry and Biology) teachers are mainly university trained and possess degrees in science disciplines. Amongst the graduates more than half (54 per cent) qualified via a post-graduate Diploma in Education Course while 40 per cent had an education component incorporated in their initial degree courses.

When the number of qualified science teachers is compared to the number of teachers actually teaching science there appears to be a shortage of KBSM Science, General Science and Physics teachers in the region of 62 per cent, 30 per cent and 13 per cent respectively (the KBSM figure may be anomalous since this is a new curriculum - most older qualified science teachers at this level are likely to have been General Science trained). On the other hand, there is a surplus in the number of Chemistry and Biology teachers in the region of 25 per cent and 57 per cent respectively.

Shortages of teachers for the various subjects have been overcome by utilising teachers whose main option was other than the subject taught. Thus from an analysis of *Table 6.2*, 26 per cent of teachers teaching KBSM science were Mathematics optionists, 15 per cent General Science optionists, and 7 per cent Biology optionists.

Table 6.2 Distribution of teachers teaching science by subject taught, location of school and main option trained in grades.

Location of school	Main option	Subject taught					
		KBSM/Sc	Gen/Sc.	Phys.	Chem.	Bio.	Total
	KBSM/Sc	66	1	0	0	1	68
	Gen/Sc	26	7	0	0	0	33
	Physics	5	7	15	0	0	27
Rural	Chemist	5	10	0	18	3	36
	Biology	13	9	0	0	22	44
	Maths	38	8	8	5	2	61
	Others	11	4	1	0	0	16
	KBSM/Sc	64	0	0	0	0	64
	Gen/Sc	27	3	0	0	1	31
	Physics	53	3	34	1	0	43
Urban	Chemist	8	8	4	44	1	65
	Biology	11	20	1	4	47	83
	Maths	50	11	15	8	3	87
	Others	15	1	2	0	2	20
Total		344	92	80	80	82	678

In the case of General Science, 32 per cent of the teachers were Biology optionists, 21 per cent Mathematics optionists and 20 per cent Chemistry optionists. In addition, 11 per cent were Physics optionists. A large proportion (29 per cent) of teachers teaching Physics were Mathematics optionists. A smaller proportion of Mathematics trained teachers (16 per cent) were teaching Chemistry. Overall the largest proportion of non-science optionists teaching science constituted Mathematics majors. Of the 678 teachers teaching science in the survey schools, 148 (22 per cent) were Mathematics optionists. Though there may be some definitional problems with the data the picture that emerges is generally consistent with national data and that from the case study schools. The other main reason for mismatches arises from the deployment of teachers between schools. In some there may be a shortage of a particular science subject teachers while in others there may be a surplus. Shortages of qualified science teachers are more acute in urban than in rural schools. This finding is consistent with that of the case studies. In rural schools the shortage of KBSM Science teachers averages about 59 per cent while for General Science it is about 85 per cent. On the other hand, in urban schools the shortage of KBSM Science teachers is 64 per cent, while that for General Science teachers is 93 per cent. As noted in 6.1.3, these apparently high rates must be treated with caution since there are defunctional problems with KBSM and General Science teachers.

There are some anomalies in the utilisation of teachers. The majority of General Science teachers (83 per cent) teach KBSM science while a significant number of the Physics optionists (29 per cent) have been assigned to teach KBSM Science or General Science. The classification General Science trained is ambiguous since lower secondary science has traditionally been taught by generally trained science teachers, as distinct from those specifically trained to teach General Science in the upper secondary In terms of the utilisation of science teachers about 35 per cent of qualified science teachers do not teach their option subjects – 39 per cent in rural schools and 33 per cent in urban schools. This represents a source of wastage in the sense that the qualified teacher per student ratio could be improved by more efficient deployment. Between 30 per cent and 50 per cent of the science optionists in three of the case study schools were teaching other subjects, whilst in another school there was an excess of 21 science teachers.

6.1.2 Teaching loads

Table 6.3 shows the average number of science teaching periods per week for KBSM Science, General Science, Physics, Chemistry and Biology teachers. It also shows the average total teaching periods per week of these teachers. General Science and Biology teachers appear to have higher loads in urban schools. On average, science teachers have a total of 23 teaching periods and 11 'free' periods in a week. This is consistent with data from the case study schools where science teachers averaged between 21 and 25 teaching periods per week, except in residential schools.

Table 6.3 Average number of science teaching periods by location of school and subject taught

Science teachers by subject taught	No. of weekly science teaching periods	
	Rural mean	Urban mean
KBSM/Sc	16.9	17.6
Gen/Sc	14.0	15.8
Physics	13.9	15.2
Chemistry	13.7	15.5
Biology	13.0	16.3
Tot		
Teaching	23.4	23.6
Periods Per		
Week		
Free Periods	10.7	11.0
Per Week		

Table 6.4 gives data on subjects taught and subjects preferred. It is perhaps surprising that so many science teachers (43 per cent) preferred to teach other subjects. These teachers may be the ones most likely to apply for transfers to other schools where they can teach the subjects they like more. Disturbingly 34 per cent of rural and 32 per cent of urban school science teachers agreed with the statement "I would rather teach in another school". Further analysis suggested that dissatisfaction was greatest in schools where science teachers were under extreme pressure to maintain high levels of achievement and in remote rural schools that were unpopular and inconvenient postings. Thus, in one of the residential schools in the case studies, interviews indicated that teachers continued employment in the school depended on their examination results. 'Low performance' teachers were advised to transfer and 'productive' teachers were discouraged from moving.

Table 6.4 Distribution of science teachers according to the subjects they most like to teach

Location of school	Subject taught	Subject preferred							
		KBSM/Sc.	Gen/Sc.	Phys.	Chem.	Bio.	Maths	Other subj.	Total
	KBSM/Sc	99	10	3	3	6	50	5	176
	Gen/Sc	7	17	3	5	3	8	4	47
Rural	Physic	0	1	16	0	0	7	0	24
	Chemis	2	0	0	16	0	5	1	23
	Biology		1	2	2	23	0	0	30
	KBSM/Sc	97	12	2	4	8	48	6	177
	Gen/Sc	8	10	2	3	9	13	1	46
Urban	Physics	0	1	38	1	1	16	0	57
	Chemistry	0	1	2	39	2	12	1	57
	Biology	2	2	1	1	41	5	1	53
Total		217	55	69	74	93	164	19	690

A further indication of teachers motivation was obtained by comparing the subjects teachers preferred to teach with those they were currently teaching. Amongst KBSM science teachers 56 per cent indicated that this was the subject they most liked to teach, 28 per cent preferred Mathematics, 6 per cent General Science and 4 per cent Biology. There were 93 teachers teaching General Science. However, only 29 per cent of them reported that it was the subject they most liked to teach and 23 per cent preferred to teach Mathematics, 13 per cent Biology and 16 per cent KBSM Science. Thirty-three per cent of Physics teachers preferred not to teach the subject and the majority of these (85 per cent) preferred to teach Mathematics. For chemistry teachers 31 per cent expressed a preference for other subjects and again the majority (68 per cent) preferred to teach Mathematics. Amongst science subjects Biology has the most satisfied teachers with 77 per cent reporting that it was the subject they most liked to teach. Among those who preferred not teaching Biology, 26 per cent preferred to teach Mathematics. In all cases most of those preferring mathematics are mathematics trained.

General science has a particularly large proportion (71 per cent) of teachers who would prefer not to teach the subject. Students who study General Science are generally those with the least interest and ability in science. As a result some teachers seem to feel 'burdened' teaching them science. This is one reason why General Science is unpopular among the science teachers. An illustration is given below.

Box. 6.1 The burden of teaching general science (School 2)

A teacher in School 2, a high performance urban school described teaching General Science as a 'terror'. He found it extremely difficult to motivate students partly due to the large class size. He also questioned the tendency to have large classes in the arts stream when these were the very students who needed the extra motivation that could be given with smaller class sizes.

The school atmosphere varied between the case study schools and this appeared to be linked to performance and the motivation of the teachers. In several but not all of the low performance schools (e.g. school 8) a laissez-faire climate seemed to prevail. Punctuality was casual, school buildings not well maintained or tidy, classroom furniture was out of place, some activities, e.g. physical education were not well organised, and teaching seemed to lack focus. Teachers and the administration appeared to have 'given up' and a resigned attitude was pervasive. By contrast high scoring schools generally conveyed a purposeful atmosphere. Two contrasting examples of how this was achieved were provided by schools 13 and 2.

Box 6.2 Contrasting reasons for high levels of motivation (Schools 2 and 13)

> In School 13, a high performance science residential school, teachers seem under constant pressure though staffing ratios are favourable. Their lives in school, during school hours and after, seemed to be governed by a rigid time-table. Teachers were generally seen rushing for classes and trying to conduct as many extra classes as possible. This was partly a response to the pressure of achievement. Teachers revealed that if there was a drop in performance in their subject they were required to furnish a written report detailing reasons for the drop.
>
> In contrast, although School 2 was a high performance school there appeared to be minimal pressure. Teachers did not seem required to achieve set targets. Yet there was an air of business about the school. There was little dawdling or wasting of time. Teachers conducted extra classes but these were on a voluntary basis. Teachers attributed this to the feeling of 'belonging' they felt with the school.

Table 6.5 shows the distribution of science teacher responses to 35 attitude items in the survey. Attitude items which show a significant difference of the 5 per cent level between urban- and rural-based teachers are marked u and r indicating which group were more likely to agree.

Table 6.5 The distribution of science teacher's responses to attitude items

	% Rural	Agree Urban	Item No.	Statements
R	95.8 92.9 90.4	91.6 86.5 93.4	66 69 96	More teaching aids Inservice courses improve my teaching Modify content to make Sc relevant to students
	87.8 85.2	84.8 87.6	67 81	Teach lighter loads than others Sc skills are more important than passing exams
R	85.0 84.9	81.5 78.8	92 98	Too much material in Sc curriculum Able students benefit from being grouped together
R	84.3	73.6	83	Malaysia needs Sc grad for development
R	84.3 81.8	75.0 80.9	71 88	Sc Panitia useful Rather be a teacher than do another job
	80.6	77.9	70	Easy access to advice on pract problems
	80.1	77.4	84	Exam results good basis for selecting students
	78.6	77.5	95	Difficult to complete the syllabus if conduct practivals
U R	77.6 76.0	83.6 66.2	73 99	Sc is too diffiult for weak students Less able students en joy practival work
	72.1	71.5	100	Less able students perform better working with able students
	70.2	70.9	87	Exams discourage teaching towards students needs
 U U	67.9 66.9 65.3	63.0 74.2 62.6	86 79 94	Exams test recall not Sc process skills Most students try hard to study Sc Materials emphasis facts than Skill/attitudes
	61.9	58.6	68	Had to provide teaching materials myself
R	61.7	56.6	93	Group pract. Are difficult because of lack of eq
R	54.9 54.3	52.1 38.7	90 82	Teaching Sc has become more difficult Sc students have more opporunities to get good jobs
R	53.7	44.2	76	Rural students find Sc more than other subjects
	49.2	48.7	80	Sc should be given more time in forms 1-3
U	46.9	62.1	75	Students should be allowed to give up Sc if found difficult
R	42.1	34.5	97	Difficult to introduce new teaching methods
	34.4	31.7	89	I would rather teach in another school
R	27.0	21.1	72	Prindipal is interested in other subjects
U	21.8 20.8	52.9 23.6	85 91	Many students take extra tuition in Sc Teachers do demonstrations more than class prac
  U	20.2 16.8 4.2	23.3 14.0 11.8	78 74 77	Many students are not interested in Sc Boys need Sc more than Girls Girls do not kike studying Sci

Note: R - Rural is higher U - Urban is higher

Table 6.5 shows that the rural school science teachers tend to agree more than the urban school science teachers on ten items. These items are statements numbered 69, 98, 83, 71, 99, 93, 82, 76, 97 and 72. It seems that a higher percentage of science teachers in rural rather than in urban schools agree that in-service training improves teaching (69), able students benefit from being grouped together (98), Malaysia needs science graduates for development (83), the Science Panitia is useful (71), less able students enjoy doing practicals (99), group practicals are difficult because of lack of science equipment (93), science students have more opportunities to get good jobs (82), rural students find science more difficult than other subjects (76), it is difficult to introduce new teaching methods (97) and that the principal is more interested in other subjects (72).

On the other hand, there are five items where urban science school teachers tend to agree more than the rural school science teachers. These are items numbered 73, 79, 75, 85 and 77. A higher percentage of science teachers in urban than in rural schools agree that science is too difficult for weak students (73), many students try hard to study science (79), students should be allowed to give up science if they find it difficult (75), many students take extra tuition to improve their science achievement (85) and that girls do not like studying science (77). Forty per cent of all teachers felt that physics was the most difficult subject for boys and 79 per cent said it was for girls.

In rural schools, it is very interesting to note that although the science teachers agree that 'in-service training improves teaching (69)' they find it more difficult to apply the 'new knowledge and skills' in their teaching and have more difficulty in introducing new teaching methods (97). The reasons could be partly because they more frequently indicate a lack of science equipment (93) though the case study data did not indicate this clearly. Though in rural schools the science panitia (71) is considered more useful it seems that it only has a limited impact on putting new ideas into practice.

Compared to the science teachers in urban schools, those in rural schools seem to possess more positive attitudes towards in-service courses, group learning, practical work and the value of science qualifications for getting good jobs. However, they do not appear to have as much support from the school principals. The rural school science teachers are more likely to perceive that the school principals are be more interested in improving the performance in subjects other than science though it is a minority who do so. Rural teachers are more likely to think that students in rural schools find science more difficult than other subjects (76) though our other data suggests that, because of its status, they are still keen to study science.

There were no differences between urban and rural teachers on the other items. The general picture from these responses is one which is favourable to science and science teaching. Most indicate their preference for teaching as a job and indicate needs for more support in terms of teaching materials, in-service courses, and curriculum development. About 80 per cent indicate that science is too difficult for weak students, strengthening the view that the teaching of average and below average students is considered a problem. Few teachers favour demonstrations replacing practicals and most disagree that girls have less need of science than boys. We cannot be sure that these statements of attitude reflect values that inform on teacher behaviour. However, the picture they present is generally consistent with other data.

6.2 How many science teachers are needed?

The previous section identified characteristics of the current teacher force and examined aspects of its deployment. This section is concerned with estimating the supply and demand for science teachers over the next ten years. National plan targets imply increases in the output of science-qualified leavers. The age cohort will grow and participation rates in Form IV and V are set to rise as automatic promotion is introduced in to these grades. More science teachers will therefore be needed. We have therefore explored the situation and undertaken new projections of science teacher demand to establish how great these needs are.

Before embarking on this analysis it is necessary to comment on problems of definition. Teachers may have been trained in Teacher Training Colleges at certificate level or in Universities. The latter produce teachers both at diploma and at degree level. The current policy is that in future all secondary school teachers will be graduates. The question that arises is which subject combinations qualify teachers to teach the different science curricula? Currently a significant number of non-science optionists are teaching science. Most are mathematics trained who, it is assumed, can teach science. There is, as far as we are aware, no formal definition of the range of initial qualifications that are considered appropriate for science teachers. A possible view is that all science graduates ought to have sufficient knowledge and ability in science to teach all science curricula at secondary school level. They will have been science students in Form VI and, until the advent of KBSM, will almost all have studied all three sciences. Since the number of Form VI students is relatively small it should be possible to find teachers for sixth form science with degrees in the relevant subjects for single subject science teaching. At Form IV and Form V level, mathematics graduates who have followed the science stream in Form VI should be able to cope with the science content of all the courses. Those mathematicians from arts stream backgrounds may have greater difficulties.

General science teachers appear to have particular difficulties with the Physics components of the curriculum. So also do Forms I-III teachers. This suggests that this area of the curriculum should be given special attention in the teacher training programmes for non-physical science graduates who are likely to teach at this level. As certificate teachers in Forms I to III are gradually replaced by graduates in science, teaching problems at this level which arise from difficulty in understanding science should diminish. If, however, a significant number of trainees are not science graduates or science stream leavers, the mastery of content may remain a problem for such teachers.

Our projections assume that science will be taught very largely by those with training to teach science subjects who have completed degree level science. As part of the change to an all graduate profession at secondary level it may be desirable to develop guidelines which specify which combinations of academic qualifications are thought sufficient to teach science at the different levels.

The view in the last five years has been that the supply of science teachers has exceeded demand. As a result various institutions of higher learning reduced and finally stopped courses in science teacher education. All universities except one have stopped producing science teachers under the integrated science with education degree programmes. This is not projected to change (as of 1991) at least until the year 1995. *Table 6.6* shows the output of science teachers from various universities in the past few years and the projection until 1995.

Table 6.6 Output of science teachers and the projection of output under the science with education programme (1985-1995)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
UM	115	122	113	91	105	0	0	0	0	0	0
UKM	-	-	-	34	62	0	0	0	0	0	0
USM	172	167	196	202	168	11	0	0	0	0	0
UPM	83	84	49	45	21	0	0	0	0	0	0
UTM	89	124	142	145	117	98	59	49	44	44	0
Total	459	497	500	517	473	109	59	49	44	44	0

Projection of teachers' demand and supply carried out by EPRD in 1989 showed that although generally the supply of pure science teachers exceeded demand, the number of teachers needed to teach General Science was still in short supply as indicated in *Table 6.7* This projection does not include the effects of automatic promotion to Form IV or the swing away from pure science subjects both of which will increase demand for general science teachers.

Table 6.7 Projection of demand and supply of general science teachers

Year	Demand	Supply	Status (+ / -)
1989	4967	4882	-85
1990	5070	4930	-140
1991	5250	4864	-386
1992	5687	4721	-966
1993	6138	4323	-1815
1994	6489	3903	-2586
1995	6829	3481	-3348

To overcome this shortage, institutions of higher learning and teacher training colleges have taken steps to introduce special programmes. Examples of these are the one year Post-Graduate Teaching Course (KPLI) to top up production of science teachers under the one-year post-graduate Diploma in Education programmes carried out by UKM, UM and UTM. The total output from these programmes is as shown in Table 6.8. It can be seen that the number of science teachers being trained has decreased in the period 1989-1990 and the output is projected to stablise further towards 1995, below 1989 levels. These figures include trainees with mathematics degrees in the KPLI programme who do not have degree level science qualifications.

Table 6.8 Total output of science teachers

Year	Output
1989	797
1990	596
1991	306
1992	635
1993	631
1994	631
1995	587

In order to project future demands for science teachers we have first calculated the provision of science teachers per student studying any science subject. This is done for individual states by taking the ratio of the number of science teachers to the total number of students in secondary schools in 1989, excluding those in the sixth-form arts classes. Two scenarios are presented; the first takes into account only science optionists teaching science, whilst the second considers all teachers teaching science (whether qualified or not) as a basis on which to calculate the ratios. *Table 6.9* shows the teacher/student ratio for each state, based on the two scenarios mentioned.

Table 6.9 Comparison of the number of teachers to the number of students studying science 1989

	Teachers teaching science						No. of science students	Science optionists tea. stud. ratio	Total tea. teaching sc. stud. ratio
	Total No. sec. sch. teachers	Scienc e option	%	Non-science option	%	Total			
Johor	7,703	996	72.2	383	27.8	1,379	156,682	0.0064	0.0088
Kedah	4,237	593	69.7	258	30.3	851	96,833	0.0061	0.0088
Kelantan	4,667	590	74.0	207	26.0	797	84,531	0.0070	0.0094
Melaka	2,271	302	74.2	105	25.8	407	47,362	0.0064	0.0086
N. Sembilan	3,273	394	70.0	169	30.0	563	59,73	0.0066	0.0094
Pahang	3,933	459	62.7	273	37.3	732	76,42	0.0060	0.0096
Perak	8,389	1,041	71.4	416	28.6	1,457	173,625	0.0060	0.0084
Perlis	804	103	76.9	31	23.1	134	13,317	0.0077	0.0101
P. Pinang	4,264	547	74.8	184	25.2	731	86,106	0.0064	0.0085
Selangor	6,380	857	75.1	284	24.9	1,141	139,78	0.0061	0.0082
Trengganu	2,582	352	76.0	111	24.0	463	48,07	0.0073	0.0096
W. Persekutuan	3,698	533	71.6	211	28.4	744	83,30	0.0064	0.0090
Sabah	4,613	331	52.8	296	47.2	627	99,442	0.0033	0.0063
Sarawak	5,410	489	56.1	382	43.9	871	118,487	0.0041	0.0074
Total	62,260	7,587	69.6	3,310	30.4	10,897	1,283,481	0.0059	0.0085

In the case where the number of science optionists only is used to calculate the ratio, Sabah records the lowest ratio of science teachers to students (0.0033), whilst Perlis has the highest ratio (0.0077).

The national unweighted average is 0.0059. Similarly, when the total number of teachers teaching science is used as basis, Sabah records a low ratio of 0.0063, whilst Perlis has a relatively high ratio of 0.0101. The unweighted national average is 0.0085. The next step is to project the number of secondary school students so as to be able to estimate the number of science teachers needed. The projection assumes the automatic promotion of Form III students to Form IV in 1994. The transition rate from Form III to Form IV is assumed at 95 per cent from then until the year 2000.

The demand for science teachers can then be calculated based on the projected number of students and the teacher/student ratios calculated. *Table 6.10* shows the projection of demand and supply of science optionists from 1990 to the year 2000. Using a ratio 0.0059 of science teachers to students gives a demand of 7,575 science optionists in 1990, and this increases by about 62 per cent by the year 2000 to 12,269. If the provision of science optionists assumes a ratio of 0.0077 (the average value for the best state in 1989) the demand becomes 9,911 in 1990 and 16,053 in 2000. Under the assumption that this demand is to be met fully in the year 2000 and the attrition rate is 2 per cent the number of fresh science optionists required yearly is 907. This figure will be 1,067 if the attrition of teachers is assumed to be 5 per cent annually.

If science is to be taught only by science-qualified optionists the demand for them is inevitably higher. The ratio of 0.0085 (which would provide enough science teachers to cover all science periods) gives a demand of 10,880 in 1990 and 17,621 in 2000. Furthermore if the demand for teachers is to assume the ratio of 0.0101 (the best current value), the demand will be about 19 per cent higher, that is 12,894 in 1990 and 20,884 in 2000.

Under the assumption that the demand for science teachers is to be met fully by science optionists in the year 2000, the number of freshly trained science optionists required yearly is 1,346 if the attrition is assumed at 2 per cent annually. If the attrition is assumed at 5 per cent, the output required annually is 1,506. Table 6.11 illustrates the status of teachers demand and supply under the conditions discussed.

Table 6.10 Projection of teacher demand and supply

Year	No. of Sec. Sch Students	Teacher Demand		Stock of Sc. Teacher		No. to be trained		Supply		Status Year	
		T/S Ratio		(2% Att)	(5% Att)	(2% Att)	(5% Att)	(2% Att)	(5% Att)	(2% Att)	(5% Att)
		0.0059	0.0077			T/S Ratio = 0.0077		T/S Ratio = 0.0077		T/S Ratio = 0.0077	
1989	1,285,422	7,598	9,942	7,587	7,587						
1990	1,281,456	7,575	9,911	7,435	7,208	907	1,067	8,342	8,275	-1569	-1637
1991	1,301,319	7,692	10,065	7,287	6,847	907	1,067	9,101	8,981	-964	-1084
1992	1,339,361	7,917	10,359	7,141	6,505	907	1,067	9,862	9,706	-497	-653
1993	1,389,653	8,215	10,748	6,998	6,180	907	1,067	10,626	10,448	-122	-300
1994	1,541,980	9,115	11,926	6,858	5,871	907	1,067	11,393	11,206	-533	-721
1995	1,691,992	10,002	13,087	6,721	5,577	907	1,067	12,163	11,979	-923	-1107
1996	1,775,186	10,494	13,370	6,586	5,298	907	1,067	12,963	12,768	-794	-963
1997	1,854,683	10,694	14,345	6,455	5,033	907	1,067	13,711	13,570	-634	-775
1998	1,929,581	11,406	14,924	6,326	4,782	907	1,067	14,489	14,385	-435	-539
1999	2,002,544	11,838	15,489	6,199	4,543	907	1,067	15,720	15,213	-219	-276
2000	2,075,507	12,269	16,053	6,075	4,315	907	1,067	16,053	16,053	0	0

Table 6.11 Projection of teacher demand and supply based on current total science teacher/student ratio

Year	No. of Science Students	Teacher demand		Stock of Sc. Teacher		No. to be trained		Supply		Status (+ / -)	
		T/S Ratio		(2% Att)	(5% Att)	(2% Att)	(5% Att)	(2% Att)	(5% Att)	(2% Att)	(5% Att)
		0.0085	0.0101			T/S Ratio = 0.0101		T/S Ratio = 0.0101		T/S Ratio = 0.0101	
1989	1285422	10913	12934	7587	7587						
1990	1281456	10880	12894	7435	7208	1346	1506	8782	8714	-4113	-4181
1991	1301319	11048	13094	7287	6847	1346	1506	9979	9860	-3115	-3234
1992	1339361	11371	13477	7141	6505	1346	1506	11180	11024	-2297	-2453
1993	1389653	11798	13983	6998	6180	1346	1506	12383	12205	-1600	-1778
1994	1541980	13092	15516	6858	5871	1346	1506	13590	13402	-1926	-2114
1995	1691992	14365	17025	6721	5577	1346	1506	14799	14615	-2227	-2411
1996	1775186	15072	17863	6586	5298	1346	1506	16011	15842	-1852	-2020
1997	1854683	15747	18662	6455	5033	1346	1506	17225	17084	-1437	-1579
1998	1929581	16383	19416	6326	4782	1346	1506	18442	18338	-974	-1078
1999	2002544	17002	20150	6199	4543	1346	1506	19662	19605	-488	-545
2000	2075507	17621	20884	6075	4315	1346	1506	20884	20884	0	0

It should be emphasized that:

(i) if nongraduate science teachers are to be replaced by science graduates, this will increase demand (currently about 50 per cent of science teachers are nongraduates);
(ii) if shortages are to be avoided in the period 1990-1995 the rate of training will have to be greater than that projected at the beginning;
(iii) if trained science teachers are deployed to teach other subjects (living skills, technology, etc.), more will have to be trained;
(iv) the pattern of option choice by students under KBSM is uncertain – it may result in severe shortages of what used to be General Science teachers if the swing away from science continues;
(v) the distribution of science teachers between States and between schools may make shortages particularly acute in some locations;
(vi) though the number of places for science optionists in training may be increased by opening courses, it may not be easy to locate sufficient experienced science educators to staff them.

6.3 Some emerging issues

Though the supply and demand for teachers was approximately in balance at the beginning of the 1990s a significant amount of science was being taught by nonscience-trained teachers at all levels. Science-trained teachers spent between 65 per cent and 75 per cent of their time teaching science on average. In addition, a little less than half those teaching science were nongraduates.

Substantial proportions of science teachers express a preference to teach other subjects – over 70 per cent of general science teachers; over 40 per cent of KBSM science teachers; about 30 per cent of physics and chemistry teachers and only a little over 20 per cent of biology teachers.

Physics is seen by most teachers as the most difficult subject in general and especially for girls. Based on current trends in the output of science teachers and the projected demand, there will be a shortage of science teachers throughout the 1990s.

Output of new graduates trained to teach science probably needs to be between 1,000 and 1,500 annually if demand is to be met. An expansion of science teacher training is therefore needed. It is important to ensure initial teacher training provides new teachers fully capable of implementing the new curriculum. It would seem desirable to enhance the links between training institutions and schools and make full use of opportunities to develop school-based teacher training to ensure training staff have experience of teaching the new curricula.

Chapter 7

Insights into science education 3: how much support is available for teachers and what resources are available?

This chapter first describes the professional support that is available to science teachers. It collates evidence on the effectiveness of in-service support for teachers, the management of science departments, the role of the senior science teacher, and the arrangements for the supervision and monitoring of science education. The second section reviews data on the availability of resources and their utilisation. The resources discussed include financial support, physical facilities such as laboratories, preparation rooms, store rooms, equipment, furniture and fittings as well as materials which encompass consumable items, curriculum materials and library books.

7.1. *How are teachers supported?*

7.1.1 In-service support

The introduction of innovations in the science curriculum has been accompanied by various in-service training courses for science teachers. Most recently training has been taking place to accompany the introduction of KBSM. The Teacher Training Division and the Curriculum Development Centre of the Ministry are responsible for organizing and conducting these in-service courses. The aims of these courses are to equip teachers with the new knowledge of science needed in the revised curriculum, introduce appropriate teaching methods and provide assistance with strategies to implement the curriculum in schools. A large proportion (over 60 per cent) of teachers in the teachers' survey reported having attended in-service courses over the years prior to the survey. All but 14 KBSM teachers had attended in-service the previous year as all teachers at this level were required to attend courses on the new curriculum. Of those attending in-service most science teachers (78 per cent) had attended 1 to 5 day courses and a smaller number (14 per cent) had attended 6 to 10 day courses. The remainder had experienced more than 11 days in-service. *Table 7.1* shows that the reaction to the courses was generally favourable. Eighty-one per cent felt that the courses had been useful in terms of acquiring new knowledge of science. In addition, 87 per cent felt that the course had been useful in terms of learning about new teaching methods and 94 per cent indicated satisfaction with the insights and assistance they had received on curriculum innovation and strategies for change. Rural teachers were slightly more likely to agree that the courses were useful in each of the three dimensions.

These results should be interpreted with caution. They do show a high level of participation in in-service activities by science teachers on the survey sample. Also it seems plausible that rural teachers derive more benefit, though the differences in the response pattern are not very great. However, these overall levels of satisfaction do not seem to be consistent either with what interviewees in case study schools reported or with our observations of practice in the classroom. An example of the satisfaction gained from in-service courses is illustrated in School 4.

Box 7.1 Benefits of in-service courses (School 4)

> The Senior Science Teacher commented that several courses had been organized by the State Department. These courses however tended to deal more with aspects like setting examination questions and less with areas related to actual teaching. She felt that there was a greater need for courses which allowed teachers the opportunity to get together and share ideas, views and experiences particularly on how to approach specific topics and make lessons more interesting. Another teacher noted that she had attended a course called "Thinking Court" organized by the State Department. While the course was interesting and aimed to help teachers develop thinking skills amongst students, it had not been organized specifically for science teachers. The teacher had not been able to apply what she had learned in any of her lessons. Time constraints and the fear that students might be penalized in examinations appeared to be other barriers she faced in applying what she had learnt in the course in the classroom.

Table 7.1 Urban and rural science teachers perception of the usefulness of inservice science courses

Location of school	Science Teachers by Subject Taught	Usefulness														
		Science (*) knowledge					Teaching (*) skills acquisition					Curriculum (*) innovation assistance				
		4	3	2	1	Tot	4	3	2	1	Tot	4	3	2	1	Total
		49	66	14	2	131	44	80	7	1	132	48	77	3	1	129
	KBSM/Sc	7	18	3	1	29	4	22	3	0	29	10	18	1	0	29
Rural	Physics	4	10	1	1	16	5	9	2	0	16	4	12	0	0	16
	Chemist	6	12	6	0	24	7	15	3	0	25	9	13	1	1	24
	Biology	4	17	5	0	26	8	14	4	0	26	9	16	0	0	25
	KBSM/sC	32	89	27	5	153	40	88	21	4	153	47	95	12	0	154
	Gen/Sc	9	17	1	2	29	8	20	1	0	29	11	15	1	0	27
Urban	Physics	7	28	6	1	42	8	26	7	1	42	11	25	4	1	41
	Chemist	8	20	12	4	44	8	28	8	1	45	16	22	4	1	43
	Biology	3	27	9	0	39	8	24	6	0	38	7	30	1	0	38
Total		129	304	84	16	533	140	326	62	7	535	172	323	27	4	526

Note: (*) 4 = Strongly Agree
3 = Agree
2 = Disagree
1 = Strongly Disagree

Source: Survey Report

The common teaching patterns found in science lessons did not suggest that in-service courses were having a major impact on the actual practice of science education. Implementation of the science curriculum, in terms of intended patterns of use, was generally not evident. Part of the reason for the difference in the images presented from the case study data and that from the survey probably lies in teachers not wishing to appear critical of the Ministry in an official questionnaire.

7.1.2 Management of science departments

The typical arrangement of staff in school science departments in terms of a managerial hierarchy is as follows:

(a) Principal/Senior Assistant
(b) Senior science teacher
(c) Science teachers
(d) Laboratory assistants
(e) Laboratory attendants.

7.1.3 Principals

School principals have the major responsibility for curriculum leadership in schools. The support of principals for particular subjects is important for the morale of staff, the resources allocated to them and efforts made to improve teaching and learning. The difficulty in relation to science is that most principals are not science specialists. Amongst the survey schools 88 per cent of principals were qualified in subject areas other than science and it is most likely that the majority finished studying science at Form V. Many will not have been science stream students. This does not mean that these principals cannot exercise leadership in the development of science education, but it does imply that what they can do will be limited by their subject expertise. This increases the significance of the role played by senior science teachers. A case in point is illustrated in School 4.

Box 7.2 Special needs of principal in the area of science education (School 4)

In School 4, the principal was as a whole very supportive of students getting the best possible overall education. Yet, by his own admission, he was hampered in the area of science education because « I am not a science person and know little of science requirements ». He admitted that his inspection of the science laboratory was limited to aspects like general cleanliness and orderliness. If a science class was in progress his observations generally centred on whether students were well behaved, noisy, etc. The principal ventured further that there was an urgent need for science teachers to « educate their principals on the specific requirements of science... to come forward and explain their needs ».

In the case study schools it was found that some principals did seem to show a lack of vision pertaining to the provision of science education. In many cases science was treated as just another subject in the curriculum. Few principals felt that the teaching and learning of science should extend beyond classroom/laboratory teaching, that science should be allocated more time in the curriculum, or that teachers needed more time than in other subjects to prepare effective lessons as a result of the work involved in setting up practical activity. A majority of principals surveyed also felt that students who studied science did not have as good job prospects as in other subjects. A significant number of principals were sympathetic to the idea that Form IV students who found science difficult should be allowed to drop the subject.

Box 7.3 Lack of vision for science education (School 13)

The Senior Science Teacher in School 13 spoke of the lack of vision among the school administrators towards promoting science education. Science was hardly spoken of by the principal and senior assistant during assemblies. There was no encouragement to extend learning beyond the classroom and beyond achievement in examinations. He added that the name changes among many science schools where the word « Science » had been dropped seemed to reflect a more general disillusion.

Case study data also seemed to indicate that with more positive attitudes the principal could play a very important role. In a minority of schools science was valued as a high status subject with special needs. The most obvious sign of this was direct interest on the part of principals in ensuring that the laboratory facilities were maintained in good condition with adequate stocks of equipment and consumable material. Relationships with the senior science teacher were also identified as critical, especially for the majority of principals with no special knowledge of science.

7.1.4 The senior science teacher

The central leadership figure in science departments is the senior science teacher. In the past no special recognition has been given to this position and this has led to problems. Some teachers have been unwilling to take on the extra responsibilities without extra pay and formal status. Others who were appointed found themselves junior to members of their department and in difficult relationships with more experienced science teachers. This situation may change under the organizational changes that allow for a senior post with responsibility for mathematics and science. It is important that the authority and responsibility attached to these posts is clearly defined if they are to be an improvement over the current arrangements. The current situation leads to problems of legitimacy. Thus several teachers questioned whether senior science teachers could observe and comment on their teaching and argued that only the principal was authorised to do this (despite, or perhaps because of the fact that the principal was unlikely to be qualified in science).

In the case study schools leadership in science matters is confined to senior science teachers. Often however the leadership is restricted to the management of the laboratory and does not extend to curriculum issues or staff development in a substantial way. In some cases even the management of laboratory was left in the hands of laboratory staff as illustrated in *Box 7.4*.

Box 7.4. Management of the laboratory by laboratory staff (School 8)

The head of science in School 8 has been with the school since 1989. However, he is new to the post of senior science teacher and seems rather unsure of what his role is. There seems to be lack of active leadership on his part with regard to the running of the science department. For example, even the ordering of equipment and consumables is left to the laboratory attendant who has been in the school since it was established in 1979.

Senior science teachers are not trained for the role and are mostly appointed on the basis of successful classroom performance. They may or may not possess management skills. They have no special call on resources to develop the science curriculum in their schools or to organise professional development activities for their staff. In a good number of the case study schools there seemed to be no particular policy developed by the science department to organise its affairs and a very limited amount of medium-term planning. Where it existed, it was generally related to organising practical examinations. In some schools there were attempts to build up resources over time according to a plan, but in most a sense of cumulative development seemed lacking. Enhancing the role of the senior science teacher and providing management training for those appointed would therefore seem a good investment.

7.1.5 Panitias

Practically all secondary schools have Science Panitias which are committees made up of the academic science staff which meet about once a semester. There are similar arrangements in other subjects. The main purpose of the Panitia is to assist in the smooth implementation of the science curricula. Priorities are intended to include facilitating teaching-learning and finding ways of improving the performance of students. How the Panitias function and how effective they are varies from one school to another and this is apparent from case study data. In practice the matters discussed in the meetings tend to revolve around administrative arrangements and the organisation of activities like quizzes, science corners, biology gardens and school visits. Case study interviews suggested that it was rare for professional issues to be the focus of discussions and that it was uncommon for Panitias to develop coordinated strategies to improve performance. Activities like peer observation, team teaching of courses, and collaborative development of enrichment material were not generally organized by the Panitia.

The survey data shows that since December 1990, 3 per cent of science teachers reported that the science panitia had not held any meeting, 24 per cent reported that it had met only once, 43 per cent reported that it had met twice and 30 per cent reported that it had met three times or more. Survey data showed that it was uncommon for principals or senior assistants to attend the meetings of the Panitia and 58 per cent of teachers reported that this had not happened, while 26 per cent indicated one or the other had attended once. The problems of increasing the effectiveness of Panitias in providing a focus for professional support appear closely related to those of strengthening the role of senior science teachers.

7.1.6 The laboratory staff

The daily management of the science laboratory is usually undertaken by laboratory assistants and attendants. They are responsible for the preparation of apparatus and chemicals required by science teachers and for maintaining laboratories in a well found condition. Laboratory staff are also actively involved in stocktaking and record-keeping. The latter aspect was quite well managed in most case study schools. The entitlement and numbers of laboratory staff in the survey schools are shown in *Table 7.2* below.

The table seems to show that schools in the main sample do not face serious problems with the number of laboratory staff. The main concern among science teachers and laboratory staff is the lack of professional training given to laboratory staff (*see Box 7.5*). In the case study schools only 29 out of 60 (48 per cent) staff were trained. However, 12 of the 29 (41 per cent) were all in one large school, indicating that the deployment of these staff was very uneven.

Table 7.2 Urban and rural schools by the entitlement and actual number of laboratory staff in case study schools

Location Performance	Lab. Asst.		Lab. Attd.	
	Entitlement	Actual No.	Entitlement	Actual No.
Urban				
High	13	12	33	31
Medium	5	4	9	9
Low	10	9	5	3
Urban total	28	25	47	43
Rural				
High	3	2	8	7
Medium	8	9	23	18
Low	10	9	17	14
Rural Total	21	20	48	39
Total	49	45	95	82
Residential Schools	31	33	81	90
Mara Schools	23	23	43	42

Source: Survey Report

Box 7.5 Training for laboratory staff (School 4)

The laboratory attendant in School 4 has had no formal training in laboratory work. She had been requested to do laboratory work in her previous school and has continued to do so in School 4. Most of her knowledge and job skills had been acquired through on-the-job training as well as from her colleagues.
In the interview, the laboratory attendant commented that there should be regular courses for laboratory staff. In her case, although she had picked up on-the-job skills, she felt rather inadequate in certain areas especially in matters related to Physics. For instance, she noted that equipment generally used in « Electricity » like ammeters and rheostats were sensitive and easily damaged. She felt she would benefit from courses that dealt with making small repairs and maintenance of such equipment.

Training for the laboratory staff has been conducted by the Curriculum Units of the State Education Offices, but the great majority are untrained. In most cases, science teachers had to equip laboratory staff with the necessary skills and often have to involve themselves in preparations for practical work. This was especially so in schools where the competency of laboratory staff was questionable and where there were simply too few to meet the workload.

Box 7.6 Laboratory preparation (Schools 4 and 7)

School 4 had only one laboratory and this was managed by a single laboratory attendant who also doubled up in attending to certain duties in the school office.
A teacher noted that she (the teacher) often helped out in the preparations for laboratory work due to constraints of time faced by the laboratory attendant.
In School 7, of the 4 laboratory staff 2 had attended in-service courses. The laboratory assistant who was in charge of the other laboratory staff had herself not attended any such course and interviews revealed her to be less knowledgeable than the others. One of the teachers interviewed doubted her competency and preferred to handle preparations herself.

7.1.7 The supervision and monitoring of science education

Several divisions of the Ministry of Education are involved in the supervision of science education in secondary schools. These include the Federal Inspectorate of Schools, the Schools Division and the Curriculum Development Centre. The Federal Inspectorate is responsible for regular inspection of schools to ensure that the quality of education is maintained. It also provides professional advice on instruction as well as the management of schools. At state level, supervision of science education is the responsibility of the Curriculum Unit. In addition, committees are set up to help strengthen the implementation of science education.

Across the case study schools, there appears to be very little direct supervision of science from the Federal Inspectorate. Only 3 of the 13 case study schools indicated they had received a visit by them in the last 5 years. The contrasting cases of schools 9 and 11 are cited in *Box 7.7*.

Box 7.7 Contrasting levels of supervision in 2 schools (Schools 11 and 9)

> There has been minimal external supervision of science teaching in School 11. In the last 10 years, there has not been any inspection by either the State Education Department or the Inspectorate regarding science in the school.
> In School 9, support in terms of supervision by parties outside the school included a visit by the Inspectorate last year when two of the teachers interviewed were observed. During the year of the case study visit the Inspectorate visited the school again and supervision included the science teachers. The Inspectorate provided feedback which the teachers generally found useful.

Where schools had been inspected, these were in all cases block inspections and not specifically for science, although some science teachers were observed in the process and constructive comments given. Contact with the State Departments for science was also minimal and generally confined to the science practical examination and special events such as Science Week. *Table 7.3* gives data on supervision of teachers as reported in the survey. It provides data on persons doing the supervision as well as the number of times supervision was carried out in the two years prior to the survey.

Table 7.3 Urban and rural schools by supervision of science teachers in the two years prior to the survey

Location of school	Supervision by	Number of times supervision				
		0	1	2	or ≥ 3	Total
	Persons within the school	8	47	90	58	203
Rural	Officers from state/ district departments	2	3	9	3	17
	Inspectors	4	20	22	6	52
	Others	1	11	10	15	37
	Persons within the school	20	69	52	53	194
Rural	Officers from state/ district departments	2	20	6	2	30
	Inspectors	4	24	15	3	46
	Others	8	19	12	9	48

Source: Survey report

The most frequent form of supervision was therefore that undertaken within the schools. This most commonly consists of observation of teaching by the principal or senior assistant. Surprisingly, inspection visits seem more common than visits from state and district departments, though it may be that some teachers were unsure of the identity of visitors. In large States science curriculum officers are spread very thinly across a large number of schools and their visit frequency must be low. Between 15 per cent and 20 per cent of science teachers seem to have had supervisory contact with external agencies during the last two years. The main mechanism for support for quality improvements, therefore, lie within the school and the arrangements that are made for school- based support. This again suggests that senior science teachers can and should play a pivotal role in supervision.

7.2 What resources are available?

7.2.1 Annual grants

The main financial resource for science in secondary schools is the per capita grant for science and mathematics which is based upon enrolment at each level of study. Apart from the government grant, some schools get contributions from the public. However the amount is small compared to that given by the government. In the case study schools there was a time lapse of between 2 and 5 months between requests for grants and the receipt of funds. Most schools appear not to find this delay a problem as they generally hold unspent balances and many suppliers are willing to wait for payment. *Table 7.4* gives data from the survey on expenditure for science. Two categories of expenditure on resources were analyzed – teaching materials and equipment. The analysis of expenditure reveals that of the total expenditure of M$1,124,350, M$751,286 (67 per cent) was spent on science equipment. Both rural and urban schools spend about the same proportion (67 per cent) on equipment. There is also little difference in the proportion of expenditure for equipment between residential schools (including MRSM) and other schools. However, rural high performing schools appear to spend a larger proportion on equipment compared to their urban counterparts.

Some more insight can be gained from case study data. *Table 7.5* gives data on the distribution of the expenditure for science education for 1989 and 1990 collected directly from case study schools. Since the sample is small it is suggestive of patterns rather than representative.

Amongst these schools rural schools spent a larger proportion of their per capita grant on consumables and teaching aids when compared to urban schools. On average for 1989 and 1990, rural schools spent about 83 per cent of their total expenditure on equipment, consumables and teaching aids compared to only 58 per cent spent by urban schools. A similar pattern was noted for schools performing below the state mean on SRP science (Form III examination) which committed 77 per cent of expenditure to these headings compared to 64 per cent in schools above the mean. Expenditure on equipment alone averaged 43 per cent across all the schools. The two special schools appeared to spend a much higher proportion on equipment.

Table 7.4 Urban and rural schools by school performance and by expenditure on teaching materials, and science equipment

Locality Perforance	Expenditure				
	Teaching Materials (1) M$	%	Science Equipment (2) M$	%	Total Expenditure M$ (1) + (2)
Urban					
high	160,700	34.0	311,730	66.0	472,430
Medium	43,775	29.0	109,379	71.0	153,154
Low	25,791	40.0	38,574	60.0	64,365
Urban total	230,266	33.0	459,683	67.0	689,949
Rural					
High	5,717	13.0	37,625	87.0	43,342
Meidum	5,360	30.0	105,079	70.0	150,439
Low	91,721	38.0	148,899	62.0	240,620
Rural total	142,798	33.0	291,603	67.0	434,401
Urban +	373,064	33.0	751,286	67.0	1,124,350
Rural					
Total					
Res. Schools	83,518	35.0	153,328	65.0	236,846
Mara Schools	73,406	38.0	117,889	62.0	191,295

Table 7.5 Percentage expenditure by school category, 1989 and 1990

Location/ performance	Year	Equipment	Consum- ables	T. Aids	P. Exam	Furn.	Renovation	Ref Books	Others
Rural	1989 1990	39.3 % 43.2 %	21.0 % 15.7 %	20.1 % 27.3 %	5.4 % 3.4 %	0.8 % 0.7 %	0.7 % 0.6 %	1.7 % 2.6 %	5.4 % 6.1 %
Urban	1989 1990	32.4 % 46.8 %	9.6 % 10.4 %	7.2 % 10.0 %	16.1 % 18.5 %	6.1 % 5.0 %	18.3 % 2.8 %	0.2 % 1.8 %	14.5 % 4.7 %
Above mean	1989 1990	41.3 % 42.0 %	13.6 % 12.7 %	5.5 % 12.5 %	23.4 % 19.7 %	3.8 % 4.7 %	5.9 % 0.8 %	1.5 % 5.5 %	3.9 % 1.6 %
Below mean	1989 1990	34.5 % 45.8 %	17.7 % 14.0 %	19.0 % 23.8 %	3.8 % 5.1 %	2.5 % 1.3 %	4.6 % 1.5 %	0.9 % 0.9 %	11.2 % 7.2 %
Special schools	1989 1990	80.8 % 62.5 %	0 % 0 %	1.0 % 0.6 %	0.4 % 0.5 %	8.6 % 0 %	0 % 0 %	0 % 0 %	9.1 % 36.4 %
Overall	1989 1990	40.6 % 46.3 %	14.9 % 12.4 %	13.7 % 18.6 %	8.8 % 8.6 %	3.4 % 2.2 %	7.0 % 1.3 %	0.9 % 2.1 %	9.0 % 8.3 %

With respect to expenditure per student, *Table 7.6* seems to indicate that all schools in the main survey spent approximately equal amounts of money per student on the purchase of science equipment with the amounts being slightly greater in high performing schools. The MARA Junior Science Colleges (MRSM) appear to invest considerably more than other types of school (M$34.80 per student compared to M$8-$12 per student in other categories of schools). In terms of the adequacy of funds (total per capita grant minus total expenditure for the year), case study data showed a surplus in four out of eleven schools for which data is available. In the rest there seem to be modest shortfalls which were met from accumulated balances from previous years. It was only in one special science school where the shortage of income over expenditure was 37 per cent that a substantial problem arose. Data from the survey also shows that on balance expenditure exceeded income in 1990. This was largely attributed to the increased expenditure brought about by the initial implementation of KBSM.

It is difficult to ascertain if expenditure is concentrated on a particular level, a particular subject or a particular school session. However, judging by the amount of practical activity observed, it appears that very little is spent specifically on General Science. The most expensive demands on equipment are made at Form VI level where the enrolments are smallest. While some case study schools experienced problems of lack of equipment for the afternoon session this appeared to be more a problem of lack of accessibility or poor management practices rather than a lack of equipment itself since enrolments in the afternoon are invariably smaller.

The basis of provision of the per capita grant is the enrolment at various levels. Small schools therefore receive less and as a result stand at a disadvantage in purchasing power. This is part of the explanation why rural schools may have to spend greater proportions of their resources on equipment. The current system provides no special assistance to maintain a full stock of science equipment where there are small enrolments.

Table 7.6 School performance by expenditure per student on teaching materials, science equipment

Locality performance	Expenditure/student (M$)		
	Enrolment	Teaching materials	Equipment
Urban			
High	31,166	5.16	10.00
Medium	11,656	3.75	9.38
Low	4,832	5.34	7.98
Urban total	47,654	4.83	9.65
Rural			
High	3,211	1.78	11.71
Medium	11,559	3.92	9.09
Low	15,337	5.98	9.71
Rural total	30,107	4.74	9.68
Urban + rural Total	77,752	$4.80	$9.66
Res. schools	13,645	6.12	11.23
Mara colleges	3,388	21.66	34.80

7.2.2 Physical/material facilities for science education

The survey explored principals' perceptions of the adequacy of facilities for teaching science. Of 65 schools which responded to this item, only 3 (5 per cent) indicated that facilities were insufficient for science and 38 per cent indicated that they were only moderately so *(Table 7.7)*. The picture that emerges is one where there appears to be little difference in the perception of the adequacy of facilities between urban and rural schools or those with high and low performance at SRP. Only 2 of the 23 principals in low performing schools indicated that facilities were insufficient.

principals in low performing schools indicated that facilities were insufficient.

Table 7.7 Sufficiency of facilities for teaching science

Location Performance	Sufficiency of Facilities			
	Sufficient	Moderately sufficient	Insufficient	Total
Urban				
High	11	7	0	18
Medium	6	2	1	9
Low	3	1	1	5
Urban total	20	10	2	32
Rural				
High	3	1	0	4
Medium	4	7	0	11
Low	10	7	1	18
Rural total	17	15	1	33
Total No. of schools reporting	37	25	3	65

Source: Principal's questionnaire

Teachers were also asked what they perceived to be the level of adequacy of particular science facilities. *Table 7.8* shows how they responded. In rural schools, teachers ranked teachers' guide books as most lacking followed by equipment for class practicals. In the urban schools teachers ranked storage facilities as the least adequate item. Lighting and ventilation, safety, and supply of consumables did not seem to be much of a problem in both categories of schools.

Table 7.8 Teachers perception of the adequacy of various facilities

Facilities	Rural rank (*) Schools order (Rr)	Urban rank (*) Schools order (Ru)	Difference in rank (Rr-Ru)
Teachers Guides	1	2	-1
Equipment for class practicals	2	6	-4
Laboratories	3	3	0
Equipment for Demonstrations	4	7	-3
Storage facilities	5	1	4
Classroom space	6	4	2
Textbooks	7	9	-2
Safety	8	10	-2
Consumables	9	8	1
Furniture	10	5	5
Lighting/ Ventilation	11	11	0

Note: (*) - 1 indicates most insufficient and 11 indicates least insufficient.
Source: Teacher's questionnaire

7.2.3 Laboratories

Laboratories are an integral component of the provision of science education. Under the Fifth Malaysia Plan, a total of 536 laboratories were planned. Of the total, 440 (82 per cent) were for pure science, 87 (17 per cent) were for KBSM Science and 7 (1 per cent) for General Science. In the survey schools the number of students per laboratory and the laboratory classroom ratio in rural and urban schools is as shown in *Table 7.9*. This indicates that the ratio of students to laboratories is significantly higher in urban schools, especially high and medium performing schools.

Table 7.9 Urban and rural schools by performance and the distribution of laboraties by science subject

Location Performance	No. of Laboratories					Student/ lab. ratio	Total No. of classrooms	Lab: classrooms ratio
	G.Sc.	Phy.	Chem.	Bio.	Total			
Urban								
High	34	21	21	18	94	332	491	1:5.2
Medium	19	5	5	4	33	353	166	1:5.0
Low	10	4	4	4	22	220	124	1:5.6
Urban total	63	30	30	26	149	319	781	1:5.3
Rural								
High	7	3	3	3	16	200	62	1:3.9
Medium	16	9	10	14	49	236	250	1:5.1
Low	50	7	9	8	74	207	395	1:5.3
Rural total	73	19	22	25	139	217	707	1:5.0
Total	136	49	52	51	298	260	1488	1:5.0

This is consistent with the fact that urban schools have higher average enrolments. Despite this, rural teachers ranked insufficient laboratory provision with the same importance as urban teachers. This may reflect less efficient management practices. Case studies indicated that all four laboratories not utilised for science were found in rural schools.

Schools have different arrangements for laboratory allocation. In schools with pure science subjects specific laboratories are allotted for Physics, Chemistry and Biology. General Science classes are generally allocated to pure science laboratories which are not being used. KBSM Science classes are normally assigned laboratories of their own, though this may not always be the case. There were a few exceptions to this practice. In case study School 2 laboratories were assigned by subject and form. Thus, for instance, all Chemistry periods at Form V level were assigned to a particular laboratory. This was advantageous in that it reduced simultaneous demands on equipment brought about by the same subject at the same level being taught simultaneously. In School 6, the MARA school, specific laboratories were assigned to specific teachers whichever group they taught.

Table 7.10 shows the rate of utilisation of the laboratories from the survey data. This rate of utilisation is based upon the number of laboratory periods allotted to classes each week compared to the total number of laboratory periods available. It does not indicate the actual utilisation of the laboratory for practical work. Overall the rate of utilisation is 71 per cent. Urban schools tend to have a higher utilisation rate (78 per cent) compared to rural schools (63 per cent). High performing schools in urban areas have the highest rate of utilisation (86 per cent).

In the case study schools, it is found that not all the laboratories were utilised for science. Of the 81 laboratories, 4 (4.9 per cent) were not utilised for science at all. These were found in the rural schools with performances below the mean. Generally, they were not utilised because there were sufficient others for use.

Table 7.10 Urban and rural schools by performance and laboratory utilisation rate

Location Performance	(1) No. of lab. periods alloted to classes per week	(2) Total No. of lab. periods available per week	Weekly utilization rate (%) (1) - (2) x 100 %
Urban			
High	2438	2833	86.1
Medium	879	1408	62.4
Low	626	815	76.8
Urban Total	3943	5056	78.0
Rural			
High	313	518	60.4
Medium	1063	1711	62.1
Low	1579	2439	64.7
Rural Total	2955	4668	63.3
Total	6898	9724	70.9

Box 7.8 Laboratories not utilized for science (School 1)

School 1 is a rural school with a total of 15 classes, 4 of which were upper secondary arts stream classes. It had no science stream classes at upper secondary level.

The school has a total of 4 laboratories, of which only 3 were used for the entire 60 period (15 x 4) weekly laboratory requirement. The fourth laboratory has been utilised as a store room for the storage of new equipment and new batches of consumable items since 1988. Teachers interviewed were of the opinion that the 60 laboratory periods could be comfortably accommodated by the 3 laboratories currently in use.

In addition, the fourth (unused) laboratory was slightly isolated from the others. Teachers also said that the school had planned to start pure science classes at the upper secondary level. The lack of sufficient qualified candidates however prevented this. This had also contributed to the laboratory not being used.

The case studies revealed that low utilisation was not confined to rural schools as is illustrated in Box 7.9 below.

Box 7.9 Under-utilisation of laboratories - an urban case (School 5)

> School 5 has 6 laboratories, 3 of which are assigned to pure science subjects. An analysis of laboratory utilisation revealed that each of the pure science laboratories was used for only 8 periods a week, (2 classes of 4 periods each). The school authorities noted that this « excess » was due to the fact that plans to introduce sixth form science in the school had not materialised.

Table 7.11 gives the average number of weekly laboratory periods per laboratory for case study schools. In most schools laboratories are needed for 20 to 25 periods a week in the morning session if all science scheduled for laboratory periods is to be accommodated. In afternoon sessions there is generally less demand as enrolments tend to be smaller. Some laboratories may therefore be closed. Urban schools have higher utilisation rates than rural schools in the morning session (32.9 compared to 26.1). Where utilisation rates exceed the number of periods in a week (generally about 35) it implies that some laboratory periods are taught in classrooms. This occurs in two schools. One low scoring rural school (5) has a very low utilisation rate and is under enrolled.

Table 7.11 Average number of laboratories/periods/week/lab. by session, school location and performance

Location/ Performance	Total No. of laboratories periods required			Total No. of laboratories utilized			Average No. of lab. periods per week per lab. available	
	Morn. Sess.	Aft. Sess.	Total	Morn. Sess.	Aft. Sess.	Overall	Morn. Sess.	Aft. Sess.
Rural								
(i) Above mean Sch. 9	198	40	238	5	3	5	39.6	13.3
(ii) Below mean	60	-	60	3	-	3	20	-
Sch. 1	116	60	176	5	4	5	23.2	15
Sch. 3	132	76	208	4	4	4	33	19
Sch. 7	68	-	68	3	-	3	22.7	-
Sch. 8	128	40	168	6	3	6	21.3	13.3
Sch. 10	108	60	168	5	3	5	21.6	20
Sch. 12	810	276	1086	31	17	31	26.1	16.2
Rural overall								
Urban								
(i) Above mean	398	40	438	8	2	10	49.8	20
Sch. 2	136	88	224	5	3	6	27.2	29.3
Sch. 11								
(ii) Below mean	100	24	124	6	2	6	6.7	12
Sch. 5	24	24	48	1	1	1	24	24
Sch. 4	658	176	834	20	8	23	32.9	22
Urban overall								
Residential								
Sch. 6	252	-	252	14	-	14	18	-
Sch. 13	156	-	156	9	-	9	17.3	-
Residential overall	408	-	408	23	-	23	17.7	-
Overall	1876	452	2328	74	25	77	25.4	18.1

7.2.4 Equipment and consumable

Case study visits revealed that in general equipment was adequate for group-work in all the schools visited for group sizes of 4 to 5 students. Although this was warranted in cases where limited equipment was available it was noticed that even in cases where apparatus was simple (test-tubes, beakers) and adequate for more groups of smaller sizes to be formed this was rarely done. Problems with insufficient equipment most commonly occurred when time-tabling was such that classes on the same topic ran simultaneously. This was especially serious in the larger schools. In most schools there was little evidence of planning to gradually increase the stock of equipment or to decrease groups size for practical work. This did not occur despite the availability of funds.

A closer analysis of the availability of the various types of equipment is given in *Table 7.12*. These were ranked according to whether equipment deemed sufficient for class practicals was available. The table shows that basic science equipment like bunsen burners and retort stands and tripods which are frequently used in class practicals are available to almost all teachers in sufficient numbers. Those items listed lowest are the ones less likely to be available, but most are available in sufficient quantities for class practicals in 75 per cent or more of the schools. Availability of many of the less common items was greater for urban teachers (significant differences at the 5 per cent level between urban and rural teachers responses are indicated by *u* in the table.

In the case study schools equipment that was most commonly found to be inadequate involved the teaching of topics related to electricity. This included ammeters, voltmeters, rheostats, transformers, circuit boards, etc. This was a common problem especially among low performing schools. Electrical topics are amongst the most difficult for students and teachers. Poor availability of equipment is likely to contribute to the problems with these topics.

Lack of maintenance appeared to be a common problem in nearly all the case study schools visited. Thus for example, in School 12, eight microscopes were found in need of repair, the fume cupboard had been out of order for two years and various other items were damaged and not available for use.

Table 7.12 Science teacher's responses to the availability of science equipment in their schools

Science equipment	N	Rural avail.	Class pract.	N	Urban available	Class practice
Bunsen Burners	285	283	93.6	361	360	94.2
Indicators	281	280	91.8	355	354	88.1
Retort stands/ tripods	290	289	91.7	364	364	94.5
Iron filings	274	269	90.0	333	333	94.6
Asbestos sheets	281	276	89.9	338	336	91.1
Glass ware	289	288	89.6	360	359	88.3
u- Thermometers	282	281	89.3	350	349	94.6
Batteries and wires	285	284	89.1	339	339	91.4
Bulbs and sockets	284	283	88.7	342	341	88.3
Magnets	272	271	87.5	330	330	90.0
Lenses	281	278	87.1	339	338	91.7
Chemical reagents	278	277	86.3	353	353	86.7
Galvanometer	272	271	86.0	330	329	85.7
Stop watch	283	280	85.0	346	345	89.6
Spring balance	280	277	84.1	346	343	87.8
Ammeter	277	276	84.1	336	335	87.5
Rheostat	273	272	83.1	339	339	85.0
Glass blocks/prisms	273	270	80.6	328	328	82.6
u- Microscopes	272	268	78.7	332	329	86.0
u- Syringes	240	236	77.5	307	303	86.1
u- Vernier gauge	274	267	76.4	324	323	86.7
Ticker timers	240	230	75.7	298	280	76.1
u- Forceps	258	255	75.3	322	320	88.4
u- Slides	253	247	72.1	315	311	82.0
u- Transformer	285	281	71.9	341	339	77.0
Sensitive balance	274	273	71.1	359	359	71.3
Optic ray box	265	262	69.8	316	315	71.1
u- J Tubes	241	225	68.0	293	272	73.9
u- Sterilising equipment	243	208	36.1	298	250	46.4

Source: Survey data. Note: u- Urban is higher than rural, (significant at 5 per cent level).

In all but one case (School 6) the level of maintenance and general cleanliness of equipment was poor. In the majority of schools visited there appeared to be very little attention to systematic and preventive maintenance. With much equipment, particularly that which required special skills to repair, the first fault was the last and was left unusable after it broke down.

Several good practices were observed in case study schools which included packing consumable chemicals in sachets for class experiments to minimise wastage and contamination of the stock; setting aside a storage area in the laboratory which was easily accessible for frequently used apparatus (e.g. test tube racks and holders, wooden splinters, pH paper) thus reducing the need to order these in advance; establishing routines for the collection and return of equipment; assigning specific laboratories by subject and Form to reduce competing demands for equipment; and routine reviews to order materials before they ran out.

7.2.5 Science library books

Libraries existed in all the case study schools. However, the proportion of science books in them varied between 10 and 15 per cent and the number of books per pupil was between 0.5 and 1.0. This is shown in *Table 7.13*. Provision was best in high scoring schools. Most science books are in English and appear not to appeal to students judging from the borrowing patterns observed. The only books that were frequently borrowed were revision books, past year examination papers and preparatory guides to examinations.

Libraries were poorly utilised and were empty for much of the time. Library periods did not figure on most school time-tables. Teachers were rarely seen in the library with or without students. When students were in the library most appeared not to be doing any serious work. Rather they seemed to be flipping through magazines and newspapers without taking notes or searching purposefully for information. Interviews with teachers revealed that few teachers assigned pupils work which required library research since students language skills were inadequate in English, and there was insufficient time in the time-table

Table 7.13 Library books by school category

Location/ Performance	School eêrolment	No. of library books		% of science books	% of No. science books per pupil
		Total	Science		
Urban schools	5365	26,216	3,792	14.5	0.7
Rural schools	7410	39,972	5,060	12.6	0.7
Below mean Schools	6400	28,666	3,155	11.0	0.5
Above mean schools	6375	37,522	5,697	15.1	0.9
Special resid. schools	1373	n.a	n.a	n.a	n.a
Overall	25,550	132,376	17,704	13.4	0.7

Note: (i) n.a. = not available.
(ii) overall totals exclude special residential schools.

Libraries were poorly utilised and were empty for much of the time. Library periods did not figure on most school time-tables. Teachers were rarely seen in the library with or without students. When students were in the library most appeared not to be doing any serious work. Rather they seemed to be flipping through magazines and newspapers without taking notes or searching purposefully for information. Interviews with teachers revealed that few teachers assigned pupils work which required library research since students language skills were inadequate in English, and there was insufficient time in the time-table

7.3 Emerging issues

A number of issues arise from this analysis which will have implications for policy and planning.

- In-service support is welcomed by teachers and high levels of satisfaction are reported in questionnaire items. However, interview data was not as positive and observation of classroom interactions suggested that in-service training has had a limited impact on the introduction of new teaching methods.

- The leadership role of principals in science education is hampered by the fact that very few are science trained. Senior science teachers have limited authority and few opportunities for training in management skills.
- Large proportions of laboratory staff are untrained and their deployment is uneven.
- External supervision of learning and teaching in science is infrequent. Most opportunities exist for within school supervision and staff development but it is often unclear who has the responsibility for this.
- Per capita grants for science appear adequate in most schools. Allocation to small schools provides no compensation for diseconomies of scale.
- Science teaching facilities are generally judged to be adequate. Most essential equipment is available in most schools. Where there are shortages these are for enough equipment for group work and in rural schools. The maintenance of equipment is problematic and shortens its working lifetime.
- Laboratory use patterns sometimes appear to lead to under-utilisation of laboratory space except in the larger urban schools were some shortages seem evident.
- The majority of library books for science subjects are in English and are infrequently used.

Chapter 8

Insights into science education 4: what can we learn from examination achievement to improve performance?

This chapter reviews examination data and offers a new analysis of performance on examination items to provide insights into areas of the curriculum where learning difficulties are greatest. It starts with a review of national examination statistics for science subjects. This is followed by interpretation of data generated by a reanalysis of 1990 examination scripts which provides insights into different patterns of achievement amongst urban and rural students, and those in high and low scoring and boys and girls schools. Though examination data only provides a partial indication of what is learned in science lessons it is the only convenient available source of insights into achievement patterns. The techniques used in the analysis could be refined and integrated more closely into the planning and curriculum development process.

8.1 Performance in public examinations

The performance of students in Integrated Science/KBSM Science (SRP) at the national level for the period 1986-1990 is shown in *Table 8.1*. The overall pass rate has remained fairly constant at around 80 per cent as has the proportion of candidates obtaining distinctions. There has, however, been a decline in the number of credits awarded, and as a consequence the number of pass grades awarded has increased.

Table 8.1 Performance in integrated science in the SRP (Form III) examination, 1986 - 1990

Year		Total No.of candid.	No. of candidates obtaining			
			Distinction (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	271,231	19,131 7.05 %	88,214 32.52 %	111,087 40.96 %	218,432 80.5 %
1987	No. %	274,720	21,694 7.90 %	86,617 31.53 %	114,851 41.81 %	223,162 81.2 %
1988	No. %	269,367	22,025 8.18 %	75,008 27.85 %	120,963 44.91 %	217,996 80.9 %
1989	No. %	271,645	22,866 8.42 %	68,594 25.25 %	122,734 45.18 %	214,194 78.6 %
1990	No. %	270,527	22,618 8.36 %	71,908 26.58 %	125,029 46.23 %	219,555 81.2 %

The results of MARA Junior Science Colleges represent the highest levels of achievement for any group of schools. These are shown in *Table 8 .2.* There were no failures amongst these students and only a handful obtained pass grades. The majority of students obtained distinctions for each year in the period.

At SPM (Form V) level different patterns emerge. First we consider the separate subject sciences where the number of candidates has been dropping due to declining enrolments in the science stream. Physics and Biology have similar pass rates, i.e. around 90 per cent. Chemistry has a lower pass rate closer to 80 per cent. The distribution of grades varies such that the proportion of distinctions and credits is greatest in Chemistry, and the number of pass grades greatest in Physics.

Table 8.2 Performance in integrated science in the SRP examination for MARA schools, 1986 - 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinct. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	1,457	876 60.1	575 39.5	6 0.4	1,57 100.0
1987	No. %	1,386	1,016 73.3	364 26.3	6 0.4	1,86 100.0
1988	No. %	1,066	591 55.4	459 43.1	16 1.5	1,066 100.0
1989	No. %	1,343	788 58.7	539 40.1	16 1.2	1,343 100.0
1990	No. %	989	711 71.9	218 22.0	60 6.1	989 100.0

Table 8.3 Performance in physics results in the SPM examination, 1986- 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinct. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	49,410	4077 8.25	19,101 38.66	18,453 37.35	41,631 84.25
1987	No. %	52,148	4123 7.91	19,677 37.73	18,864 36.17	42,664 81.81
1988	No. %	53,086	6338 11.94	22,552 42.48	17,932 33.78	46,822 88.20
1989	No. %	48,619	6173 12.70	21,096 43.39	16,539 34.02	43,808 90.10
1990	No. %	46,739	3892 8.32	20,973 44.87	16,874 36.10	41,739 89.30

Chemistry and Biology.

The pass rate in Biology and Physics appears to have improved in recent years. The number of distinctions in Biology also appears to be increasing. *Tables 8.3, 8.4* and *8.5* present the national results for Physics, Chemistry and Biology.

Table 8.3 Performance in physics results in the SPM examination, 1986 - 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	49,410	4077 8.25	19,101 38.66	18,453 37.35	41,631 84.25
1987	No. %	52,148	4123 7.91	19,677 37.73	18,864 36.17	42,664 81.81
1988	No. %	53,086	6338 11.94	22,552 42.48	17,932 33.78	46,822 88.20
1989	No. %	48,619	6173 12.70	21,096 43.39	16,539 34.02	43,808 90.10
1990	No. %	46,739	3892 8.32	20,973 44.87	16,874 36.10	41,739 89.30

Table 8.4 Performance in chemistry in the SPM examination, 1986 - 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	49,056	7054 14.38	21,364 43.55	11,097 22.62	39,515 80.55
1987	No. %	51,470	6412 12.39	20,139 38.92	12,353 23.88	38,904 75.19
1988	No. %	52,922	8220 15.53	22,934 43.34	11,152 21.07	42,306 79.94
1989	No. %	48,535	6717 13.84	22,541 46.44	10,905 22.47	40,163 82.75
1990	No. %	46,674	4895 10.49	21,526 41.21	10,625 22.76	37,046 79.37

Table 8.5 Performance in biology in the SPM examination, 1986 - 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Tota l No. of passes (1 - 8)
1986	No. %	46,881	3458 7.38	23,550 50.23	13,443 28.67	40,451 86.28
1987	No. %	49,488	3948 7.98	22,013 44.52	15,009 30.33	49,488 82.78
1988	No. %	50,722	4702 9.27	22,383 44.13	17,173 33.85	50,722 87.26
1989	No. %	46,141	4551 9.86	20,735 44.94	15,280 33.12	46.141 87.92
1990	No. %	44,095	5428 12.31	21,290 48.28	12,775 29.97	39,493 89.56

In General Science, the science subject taken by over 70 per cent of the students in the SPM, the national pattern of results is significantly different as shown in *Table 8.6.* Compared to the other science subjects, performance is consistently lower with overall pass rates between 65 per cent and 70 per cent. Only 4 per cent of students achieve distinctions. The number obtaining pass grades is typically between 35 per cent and 40 per cent.

Table 8.6 Performance in General Science in the SPM examination, 1986 - 1990

Year		Total No. of candid.	No. of candidates obtaining			
			Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
1986	No. %	99,702	4,442 4.45	31,318 31.41	31,903 31.20	67,669 67.9
1987	No. %	100,312	3,541 3.53	24,762 24.60	37,993 37.82	66,146 65.9
1988	No. %	106,844	3,710 3.47	23,585 22.07	41,677 39.01	68,972 64.6
1989	No. %	111,080	4,086 3.68	31,749 28.58	41,001 36.91	76,836 69.2
1990	No. %	111,267	4,478 4.02	28,750 25.84	39.169 35.20	38,870 65.1

These overall patterns of performance can be contrasted with those found in residential and MARA Junior Science Colleges. These show impressive levels of achievement as can be seen from *Tables 8.7* and *8.8.* Generally, performance in residential schools (fully residential and science residential) and MARA Junior Science Colleges for 1989 was high with pass rates above 95 per cent for all science subjects. Notably, General Science had the highest percentage of candidates who scored distinctions (49 per cent) by a large margin. All the pure science subjects showed similar patterns of performance with the bulk of the candidates obtaining credits. Generally, about 14 per cent of candidates in residential schools scored distinctions for the pure science subjects. In MARA Junior Science Colleges the figure was 25 per cent. Thus while overall pass rates were similar for MARA and residential schools, the former appeared to have a better profile of results.

Table 8.7 Performance of residential school candidates in science by subjects, 1989

Subject		Total No. of candid.	No. of candidates obtaining			
			Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (1 - 8)
General Science	No. %	850	422 49.64	410 48.24	17 2	849 99.88
Physics	No. %	3351	505 15.07	2147 64.07	659 19.67	3311 98.81
Chemistry	No. %	3352	454 13.54	2199 65.60	553 16.50	3206 95.64
Biology	No. %	3346	450 13.45	2229 66.62	599 17.90	3278 97.97

Table 8.8 Performance of MARA school candidates in science by subject, 1989

Subject	No. of candidates obtaining			
	Distinc. (1 - 2)	Credits (3 - 6)	Passes (7 - 8)	Total No. of passes (3- 8)
Physics No. % cand. who passed	525 26.7	1254 63.7	189 9.6	1968 99.9
Chemistry No. % Cand. who passed	536 27.6	1213 62.5	193 9.9	1942 98.6
Biology No. % cand. who passed	355 21.6	1099 66.8	192 11.7	1546 99.5

The analysis of SRP and SPM examination results can be extended by considering the pattern of results in urban and rural schools in the main school sample of the survey. Data on performance in Integrated Science shows that only 13 per cent of rural schools had a proportion of distinctions above the national mean of 8 per cent. On the other hand, 63 per cent of urban schools scored above this level. In 80 per cent of the rural schools in the sample more than 50 per cent of students only achieved pass grades (P7 and P8). In General Science 36 per cent of rural schools and 70 per cent of urban schools have pass rates above the national mean, and no rural school scored above the national average proportion of distinctions (4 per cent). In 75 per cent of these rural schools, 75 per cent of candidates failed the subject or achieved pass grades only (P7 and P8). There are similar though smaller differences in pure science subjects with about 30 per cent of rural schools and 70 per cent of urban schools scoring above the national average pass rate (84 per cent) in SPM.

Table 8.9 shows overall performance of schools in urban and rural areas on SRP (Form III) in 1990 in the main sample. Amongst the urban schools 56 per cent fall into the high scoring category in integrated science. In sharp contrast amongst rural schools, only 12 per cent are high scoring.

Table 8.9 School performance in intergrated science, SRP, 1990, by locality

	Performance						
Locality	High		Medium		Low		Total
	No.	%	No.	%	No.	%	
Urban	18	56	9	28	5	16	32
Rural	4	12	11	33	18	55	33
Total	22		20		23		65

High performance schools are generally schools with enrolments of more than 1,600 students. About 50 per cent of the 22 high performance schools have an enrolment of more than 1,600. On the other hand, low performance seems to be concentrated in schools with enrolments of less than 1,200 students. Of 23 schools in this category 17 have enrolments below 1,200 (*Table 8.10*). This is partly the result of interaction effects – more of the larger schools are in urban areas.

Table 8.10 Performance in integrated science SRP, 1990, by enrolment and by locality

Locality/ Performance	Enrolment					
	N	L 500	501 - 800	801 - 1200	1201-1600	More 1600
Urban						
High	18	0	2	2	3	11
Medium	9	1	1	2	1	4
Low	5	1	1	2	0	1
U. Total	32	2	4	6	4	16
Rural						
High	4	2	0	1	1	0
Medium	11	2	2	2	2	3
Low	18	3	7	3	4	1
U. Rural	33	7	9	6	7	4
Total	65	9	13	12	11	20

Source: Principals' questionnaire

It is also the case that double session schools are disproportionately represented amongst those which are high performing. This reflects pressures of access to high performing schools which results in them enroling more students than there is classroom space for in a single shift. It is compounded by the fact that high scoring schools are predominantly urban where the demand for places is greatest and class sizes largest. *Table 8.11* illustrates this.

Table 8.11 School performance by session

School performance	School session			
	N		Double	Single
High performance	22	No. %	20 90.91	2 9.09
Medium performance	20	No. %	15 75.00	5 25.00
Low performance	23	No %	11 47.83	12 52.17
Total	65	No. %	46 70.77	19 29.23

Performance by state indicates that Wilayah Persekutuan has the highest proportion of high scoring schools. Perak has a fairly even distribution of school performance and Terengganu has a majority of low performing schools. Sarawak also has a large number of low performing schools. In our sample controlled schools with special classes (Rancangan Khas) for rural students were distributed evenly between high and low achievement categories.

The baseline study and survey did not examine the performance of students at the STPM level. Nevertheless, results obtained from the two case study schools with Form VI Science provide two contrasting examples of science achievement at this level.

Data from the case study schools shows that there is a high correlation between results in science and other subjects in the SRP. There is a strong relationship between performance in science and mathematics and a fairly strong relationship with English. There is a lower correlation with performance in Malay.

Box 8.1 Contrasting performance in the STPM examination (School 2 and 9)

School 2 has shown a consistently high performance in science at STPM level. For the period 1988 to 1990 typically about 68 per cent obtained principal level pass for Physics, 86 per cent for Chemistry and 84 per cent for Biology. In addition, on an average, about 4 per cent obtained Principal A for Physics, 7 per cent for Chemistry and 11 per cent for Biology.
In contrast in School 9, no candidate obtained a principal level pass in either Physics or Chemistry for the period 1986-1989. The situation improved somewhat in 1990 when 1 out of 20 candidates obtained a principal level pass (E) for Physics and one for Chemistry. The situation was slightly better for Biology where in 1990, 4 candidates obtained principal level passes.

Table 8.12 Inter-correlation of SRP results in different subjects

	Malay	English	Maths	Science	History	Geog.
Malay	1.00					
English	.453	1.00				
Maths	.433	.627	1.00			
Science	.465	.682	.781	1.00		
History	.590	.636	.631	.726	1.00	
Geography	.489	.588	.703	.736	.759	1.00

Students who took science in Form VI in the case study schools were found to have relatively good results in both Science and Mathematics. In a group of four schools 51.2 per cent obtained distinctions in Science and 80.0 per cent in Mathematics. Of the rest, the majority had very strong credits (C3) in both subjects. One extreme was represented by School 2, a high performance urban school, where 96 per cent of students in Form IV science had obtained at least a credit 3 (C3) in Integrated Science for the SRP of 1990. Of these 77 per cent had obtained distinctions. For Mathematics, 99 per cent of the students had obtained at least a credit 3 (C3) in the SRP and of these 93 per cent scored distinctions. The other extreme was School 3, a rural low performance school, where there were 14 pure science students in Form IV. Of these 8 (57 per cent) students had obtained grades better than credit 3 for Integrated Science and 10 for Mathematics. Only 1 student obtained distinctions in both subjects.

8.2 The analysis of performance question by question

The more detailed analysis of performance on SRP and SPM science examination questions that we have conducted gives some additional insights into how much students learn, how performance differs between students in different types of schools, and which topics cause particular difficulties. This analysis was conducted on student samples drawn from the 1990 SRP in Integrated Science and re-marked by the Examination Syndicate. The sample was chosen to represent different categories of school (residential, urban and rural, and high and low scoring, girls and boys schools). School examination centres were selected in each category, and all students in the centres included. At SRP level 5,706 scripts were re-marked representing about 2.4 per cent of the population of candidates. At SPM level the sample was 6,002 for General Science, 5,058 for Physics, 5,047 for Chemistry and 4,966 for Biology. This represents about 5.5 per cent of General Science candidates and about 11 per cent of single subject science candidates. The Technical Appendix contains more details of the sampling.

It is implicit in this analysis that the examination papers are accepted as a balanced test of science achievement. We are concerned here with analysing performance, not the examination itself. Particular results apply only to the examination sample they are derived from. They can be used to draw attention to general implications which need to be confirmed by further analysis.

First, we can examine overall patterns of performance as shown in *Table 8.13*. This shows the results of analyses of examination papers for the different subjects on samples of urban (U) and Rural (R) high (H) and low (L) performance school students, and those in boys (L) and girls (P) schools. The groups of schools selected were at the extreme range of performance.

Table 8.13 Performance of student samples from urban, rural, high, low boys and girls schools on SRP and SPM science subjects

	Urban High	Rural High	Urban Low	Rural Low	Boys	Girls	Population
SRP Integ. science (Total = 75 questions) Mean S.D.	47.7 13.3	30.0 11.2	24.2 11.1	21.8 6.7	46.6 14.6	46.6 14.1	31.1 13.9
SPM General science (Total = 40 questions) Mean S.D.	21.9 7.7	17.6 6.1	17.5 5.7	16.2 5.7	19.7 6.8	21.2 7.6	18.2 6.8
SPM Physics (Total = 40 questions) Mean S.D.	21.3 8.2	17.7 7.6	15.2 6.4	13.1 5.5	21.9 7.8	20.4 8.2	19.7 7.7
SPM Chemistry (Total = 40 questions) Mean S.D.	25.3 8.6	21.7 8.8	18.9 7.7	17.9 6.9	24.9 8.6	25.8 8.7	23.6 8.7
SPM Biology (Total = 40 questions) Mean S.D.	26.2 6.8	23.4 7.2	20.9 6.0	20.4 5.5	26.2 6.6	26.6 6.9	24.9 6.8

For the SRP Integrated Science (75 items), there was a marked difference in performance between urban and rural schools. On an average, candidates scored 39 per cent more marks in the urban school sample (calculated by comparing the average of urban high + urban low schools with the average of rural high + rural low schools). This pattern repeated itself at SPM level (40 items) though the differences were smaller (16 to 19 per cent for General Science and Physics, 7 to 10 per cent for Chemistry and Biology). High scoring school students averaged 69 per cent more marks than low scoring school students in the SRP. At SPM level the differences in favour of high scoring students were 17 per cent for

General Science, 20 per cent for Biology, 28 per cent for Chemistry and 37 per cent for Physics. As the sample was constructed from extreme cases of performance, these variations probably represent the maximum range in the normal school system. Since SPM single subject science groups are selective, it is to be expected that the range in performance for these is less than for SRP where all students take the examination.

There are several tentative conclusions that can be drawn from the table. First, the population means (averages) for overall achievement at SRP suggests that average candidates succeed in answering about 40 per cent of the 75 examination questions correctly. Analysis of candidates' average grades in the schools chosen for the main survey sample suggests that low scoring SRP students are concentrated in normal government rural schools. In this sample of selected examination centres about half the children scored below 30 per cent of the marks available. Since this is a multiple choice examination with typically four or five alternative answers a proportion of these marks could have been obtained by chance guessing. This may not be felt to be a satisfactory situation.

In contrast, most students following SPM pure science subjects score at least 50 per cent with the exception of Physics in which performance, in terms of the number of questions answered correctly, is significantly worse than in the other subjects. The performance in SPM General Science suggests that the average candidate scores 45 per cent, the lowest average of all the SPM science subjects. It should be remembered that these observations only apply to the multiple choice part of the SPM.

Second, the pattern of results in the five examinations is as expected from the sampling. That is, there is a progression from rural low, through urban low, rural high and urban high scoring students. It is noticeable however that this progression is weakest in General Science, though the schools from which the SPM sample was chosen remain constant. This suggests surprisingly that there is relatively little difference in the quality of teaching of General Science except in urban high schools, unlike in the separate subject sciences. From a secondary analysis of examination data we note that there appears to be a low correlation between performance of schools in pure science and in General Science. Exploring the possible reasons for these results further is complex. However, the simple explanation that General Science teaching, and the conditions under which it takes place, does not vary greatly between schools and is of relatively low quality, is consistent with data from other parts of this research.

Third, though General Science has the lowest national average score, Physics performance of students in low scoring urban and rural schools is actually below that of General Science. Interpreting the significance of this is not straightforward. The Physics students are not the same students and are selected in a different manner to the General Science students. The examinations themselves differ in relative difficulty. No doubt, the pattern of differences in the quality of teaching and learning and resources also varies. What may be significant is that the gap in performance in Physics between high scoring urban schools and low scoring rural schools is greater than in the other separate sciences. Urban high scoring schools average 63 per cent more than rural low scoring schools in Physics, but only about 30 per cent more in Chemistry and Biology. In this case these are the same students so a change in student population is not the reason. This suggests that achievement in Physics is particularly problematic in rural and urban low scoring schools.

We now turn to consider what item analysis can tell us about the most difficult types of questions. The simplest way to do this is to focus on the SPM Integrated Science since this is taught to all students. More detailed analysis is available in a separate Performance Analysis Report for both SRP and SPM. The same techniques have been used in the analysis of results at both levels.

If we take the ten easiest questions (facility = 0.56 or greater, range 56 per cent to 78 per cent) and the ten most difficult questions (facility = 0.26 or less) for the national population we find in general, the easiest questions are those which involve the recall of information and the most difficult are those that require higher order cognitive skills including comprehension and synthesis. However, it is important to note that there are exceptions. Thus the third easiest question (facility = 0.71) concerning density, involves identifying which of several objects floating in a beaker is of least density. This requires an understanding of the concept of density and therefore has an element of comprehension skill. By contrast the fourth most difficult question (facility = 0.22) requires candidates to identify which organ in the body converts glucose to glycogen and therefore requires predominantly knowledge of the different functions of the organs named. Thus some knowledge/ recall questions can be relatively difficult and some comprehension questions can be relatively easy, though in general the opposite appears true. From this we can infer that improving performance in science will not be simply a matter of improving higher order cognitive reasoning, desirable though this may be. There will need to be a balance between these skills and the acquisition of factual knowledge. Indeed, the performance of the lowest scoring students will be obtained from the easiest questions, most of which will be operating at the knowledge/recall and comprehension levels. Improving their performance involves firstly improving their scores on these types of questions if higher level questions are generally of greater difficulty.

The questions can be broadly classified into subject areas, though the curriculum is itself integrated. When this is done about 44 per cent of all of the questions are Physics-based, 19 per cent are Chemistry-based and 37 per cent are Biology-based. The ten most difficult questions include a disproportionate number of Physics questions and only one Chemistry-based question. The ten easiest questions are all either Biology- or Physics-based. There is therefore an implication that some parts of Physics are more difficult for average students than other parts of the curriculum. Three of the six Physics-based questions among the ten most difficult are on electricity and electronics, two involve an understanding of kinetic theory, and one the transmission of sound in outer space suggesting these are some of the areas that may need special attention.

To explore further we have analysed performance of students in high and low scoring schools, urban and rural students, and boys and girls. In each case we have identified the ten questions where the differences in performance are greatest. This has been achieved by ranking facility values for the different groups and seeing where the differences are greatest. We have also used the method of comparing facility values directly. Though there are differences in the results between these methods for statistical reasons, they do not produce radically different findings. For simplicity the data below is based on relative ranking. Thus Hi-Lo rank in *Table 8.14* represents the difference in rank of the question facility value between high and low scoring schools. Where the rank in high scoring schools is smaller than in low scoring schools this means the question is relatively more difficult in low scoring schools and vice versa. A hypothetical example makes this clear.

Example:

Question number	Rank High scoring schools	Rank low scoring schools	Hi-Lo
1	5	10	-5
2	23	5	18

Here question 1 is the fifth easiest for students in high scoring schools and the tenth easiest in low scoring schools. The difference in ranks is -5. This indicates that the first question is relatively easier for students in high scoring schools. Question two shows the opposite situation. *Table 8.14* shows the actual results of the analysis of students in high and low scoring schools.

The largest relative differences in performance between high and low scoring students appear at the top of the table which contains those questions where low scoring students do relatively well. Question 43 is concerned with the behaviour of plotting compasses in a magnetic field around a wire carrying an electric current, a common and simple experiment. Question 2 asks for the instrument best used in measuring the diameter of a glass rod. Measurement is one of the introductory parts of science and content in this area will be reinforced frequently throughout the curriculum. Question 75 is about the size of soil particles and is likely to be easier for rural students (see below). Question 73 concerns a man standing on a plank and the most stable arrangement of supports. It is a real world example which may make it relatively easier for less able students. Question 9 requires an understanding of absorption in liquids and question 70 needs the identification of excretion products in humans.

Table 8.14 Differences in performance between students in high and low scoring schools

		U/Hi	R/Hi	U/Lo	R/Lo	Pop		
N		1009	840	925	685	237731		
Mean		47.70	30	24.20	21,80	31.10		
S.D.		13.30	11.20	11.10	6.70	13.90		
	Item No.	Facility Values					Rank Hi-Lo	Subject area
Low scoring relatively easy								
	43	.46	.32	.34	.30	.36	25.50	Physics
	2	.35	.25	.26	.26	.30	23.50	Physics
	75	.59	.47	.39	.36	.44	17.50	Physics
	73	.60	.48	.38	.38	.49	15.50	Physics
	9	.67	.56	.46	.48	.54	14.50	Chemistry
	70	.43	.27	.26	.23	.30	14.50	Biology
	72	.50	.41	.28	.33	.38	13.50	Biology
	54	.50	.36	.28	.30	.38	12.00	Physics
	30	.41	.28	.23	.26	.26	11.50	Biology
	61	.68	.54	.42	.39	.52	9.50	Physics
High scoring relatively easy								
	6	.68	.40	.29	.23	.40	-11.50	Physics
	19	.57	.27	.19	.16	.27	-13.00	Physics
	38	.66	.37	.29	.17	.38	-14.50	Biology
	45	.60	.30	.22	.15	.33	-18.00	Physics
	46	.85	.56	.33	.34	.52	-19.00	Chemistry
	17	.70	.40	.28	.21	.38	-19.00	Physics
	11	.79	.44	.32	.23	44	-20.50	Biology
	48	.64	.22	.18	.13	.29	-20.50	Chemistry
	69	.79	.44	.28	.22	.44	-25.50	Physics
	31	.86	.59	.34	.27	.51	-28.50	Biology

By contrast low scoring students have greater difficulty with questions in the bottom part of the table. Question 31 is about the voluntary nature of various actions – it may be relatively difficult because breathing is included as autonomic rather than voluntary. Question 69 is concerned with the rate of evaporation from the surface of a liquid and requires a careful understanding of humidity and other factors that influence the rate of evaporation. Question 48 provides data on chemical tests on an unknown substance. This is a piece of analytical chemistry only likely to be experienced and understood in good teaching environments. Question 11 concerns the physical properties of sperm which requires good physiological knowledge. Question 17 explores the reasons for the movement of clouds and offers some unfamiliar alternatives. Question 46 is about the addition of lime to soil and, perhaps surprisingly, is understood relatively better by high scoring students who are predominantly urban.

We note that there are examples of both knowledge/recall and comprehension and analysis questions in both groups. Thus it is not simply the case that low scoring students are unable to answer questions at higher cognitive levels. It seems to depend on how the question is asked and how familiar the context of the question is.

Table 8.15 shows differences in performance between urban and rural students. Question 72 is relatively easier for rural students. It is concerned with identifying the muscles used in bending the arm. Question 54 which asks what happens when a syringe full of water is compressed concerns a piece of equipment that is fairly widely available. Question 73 presents a diagram of a man standing on a plank reaching up to paint a wall and asks how the plank should be supported for maximum stability. This may be a situation more familiar to rural students. Question 30 asks for the name of the technique used to separate chlorophyll using alcohol, an experiment which is simple to perform in rural schools. Question 75 is about the size of soil particles and the physical properties this gives to earth. Those in farming communities will have the most direct experience of the content of this question. Question 16 asks for the location of the zygote in human females and is a recall question which is relatively easy.

Table 8.15 Differences in performance between urban and rural students

Item		U/Hi	R/Hi	U/Lo	R/Lo	Pop		
N		1009	840	925	685	237 731		
Mean		47.70	30	24.20	21,80	31.10		
S.D.		13.30	11.20	11.10	6.70	13.90		
	Item No.	Facility values					Rank Urb-Rur	Subject area
Low scoring relatively easy								
	72	.50	.41	.28	.33	.38	22.50	Biology
	54	.50	.36	.28	.30	.38	18.00	Physics
	73	.60	.48	.38	.38	.49	16.50	Physics
	30	.41	.28	.23	.26	.26	16.50	Physics
	75	.59	.47	.39	.36	.44	15.50	Biology
	16	.67	.58	.40	.39	.53	13.50	Biology
	47	.50	.34	.28	.26.35	.35	13.50	Chemis.
	71	.40	.30	.25	.22	.31	12.50	Biology
	2	.35	.25	.26	.26	.30	11.50	Physics
	9	.67	.56	.46	.48	.54	10.50	Chemis.
High scoring relatively easy								
	42	.57	.26	.25	.16	.28	-10.50	Physics
	7	.69	.38	.35	.30	.43	-10.50	Biology
	38	.66	.37	.29	.17	.88	..12.50	Biology
	51	.63	.26	.27	.19	.33	-12.50	Biology
	48	.64	.22	.18	.13	.29	-13.50	Chemis
	66	.62	.22	.18	.13	.26	-14.00	Physics
	53	.67	.30	..27	.20	..37	1.4000	Chemis.
	33	.69	.33	.34	.26	.39	-14.00	Chemist.
	33	.69	.33	3.4	.26	.39	-14.00	Biology
	28	.66	..26	.31	.21	.36	-19.50	Physics

Those questions that rural students perform relatively poorly on include Question 28 where the difference indiffiuclty is greatest. This asks about the colour remaining after light has passed through a prism and two coloured filters – a difficult question about an experiment that may not have been conducted. Question 33 is a complex question about transport across cell boundaries requiring detailed knowledge of cell structure. Question 53 concerns methods used in the prevention of rust which include tin-plating as well as the outer-space, an unfamiliar concept to most rural populations. Question 48 asks about the difference between high and low scoring students. This is the kind of experiment that may not have been treated well in rural secondary schools. It is also conceptually demanding. Question 51 concerns the medhod cockroaches use for sensing their environment and may be difficult for students because of the unfamiliar scientific terminology used. Question 11 asks about the characteristics of sperm – rural children may find this difficulty because it requires a scientific knowledge of physiology. Rural students perform relatively well on question 16 which is also on reproduction (in this case on the location of female organs).

It is particularly interesting to note that there are some questions (questions 72, 30 and 9) where rural low scoring students do absolutely better (the facility value is higher) than urban low scoring students despite having a significantly lower average score. Indeed, on Question 30 they perform at the same level as the average student nationally, though the average score of rural students is 30 per cent less than that for the population as a whole. Understanding more about why this is so, and conversely why the gap between urban and rural students is so much larger on other questions, should help identify interventions that could close the gap.

Differences in performance between boys and girls were explored by analysing the performance of students in single sex schools since this was the only practicable option available. The differences in performance this method produces may not be characteristic of general differences between boys and girls, since the sample is made up of very able children who are being educated in single sex schools which has been known to effect differences in science performance in other countries. The schools are all high scoring schools as can be seen from the overall means (46.6). The differences in performance are shown in *Table 8.16*.

Table 8.16 Differences in performance between boys and girls

		Boy	Girl	Pop.		
N		733	751	137 731		
Mean		46.60	46.60	31.10		
S.D		14.60	14.10	13.90		
	Item No.	Facility values			Rank Boy/girl	Subject area
Girls easier than boys						
	45	.54	.63	.33	17.00	Physics
	13	.57	.66	.37	16.00	Biology
	36	.70	.81	.48	14.00	Biology
	33	.61	.69	.39	14.00	Biology
	7	.60	.67	.43	13.00	Biology
	12	.51	.59	.29	13.00	Biology
	26	.56	.63	.32	13.00	Chemistry
	72	.47	.55	.38	11.00	Biology
	67	.46	.52	.32	10.00	Chemistry
	37	.45	.49	.26	9.00	Biology
Boys easier than girls						
	55	.72	.68	.48	-8.00	Phys/Chem.
	23	.57	.48	.24	-10.00	Physics
	43	.54	.46	.36	-11.00	Physics
	42	.57	.50	.28	-11.00	Physics
	61	.71	.66	.52	-11.00	Physics
	20	.69	.61	.40	-14.00	Physics
	19	.58	.48	.27	-17.00	Physics
	68	376	.60	.50	-31.00	Physics
	22	361	.38	.30	-32.00	Physics
	57	.71	.48	.41	-38.00	Physics

It is striking that all ten of the questions on which there is the greatest difference in performance which disadvantages girls are Physics-based. In contrast 70 per cent of the questions where girls perform best are biological. This presumably results from some mixture of the quality of the teaching of different aspects of science in the schools and from the dispositions of the students.

Girls scored relatively poorly on Question 57 which asks for the electrical energy generated by a dynamo driven by falling weights, an uncommon laboratory experiment. Question 22 concerns the appropriate installation of fuse wire in a fuse box. Question 68 enquires about the electrical effects of moving a copper wire in a magnetic field, again using a diagram of a laboratory experiment, and Question 43 explores the magnetic effects of passing a current through a wire. Questions 19, 20, 23 and 42 provide diagrams of simple electrical circuits and ask about differences in the brightness of bulbs or the current that flows when changes are made in the circuit. Question 61 needs a knowledge of the properties of tungsten filaments in light bulbs. Question 55 is the only question that is not electrical in character and this is primarily assessing an understanding of thermal radiation and reflection.

Those questions girls did relatively well on included Question 45 which was a calculation on the force in Newton's needed to lift a weight. Question 13 requires knowledge of the functions of different parts of a cell and Question 33 of the functions of different plant tissue. Question 36 asks for identification of parts of a tooth. Question 7 requires knowledge of the path of air to the lungs and Question 12 of the process of respiration in plants. The volume of acid required to neutralize an alkali is the subject of Question 26 and Question 67 requires matching solvents with different substances. Question 72 asks about the muscles involved in bending an arm and Question 37 requires knowledge of leucocytes.

Thus there is overwhelming evidence that differences in performance between girls and boys are concentrated in Physics, in general, and electricity in particular. Overall 19 per cent of SRP questions in 1990 were related to electricity and as much as 40 per cent of the Physics questions were electrical in nature. It seems clear that if more attention was given to the teaching of electrical topics in these girls schools, or if the proportion of electrical questions was reduced, difference in performance between girls and boys would diminish. The problem may have an interactive dimension if difficulties amongst female students with Physics-based topics identified in this analysis are common amongst female teachers who teach in girls schools, as suggested in one case study school.

The analysis of performance at SPM is not as straightforward as at SRP. The General Science students are not the same as those taking the pure sciences and cannot be directly compared. Indeed, single subject science students are a selected group. Many students in urban schools have rural origins. The format of the paper is not all multiple choice and analysis requires an understanding of each of the questions set in the four papers. Thus the patterns found at SPM are not necessarily an extension of the SRP patterns. The separate Performance Analysis Report begins the process of unravelling some of the patterns by subject.

8.3 Concluding remarks

The techniques that we have developed provide a powerful method for analysing those aspects of science achievement tested in public examinations which are most problematic for students. They also indicate that while achievement in some areas of the curriculum is high it is unsatisfactory in others. Clearly all the science curricula can be taught well and a majority of children can master many of the concepts, as evidenced by the performance of the higher scoring schools at SRP where science is non-selective and all children take it. Most significantly for this study, performance analysis can help identify both where learning difficulties are greatest and where there are large differences in performance between groups of students – high and low scoring, urban and rural, boys and girls. This then provides the opportunity to focus particular attention on these areas to improve performance overall and reduce differences between the groups. It suggests the need for further research to refine the diagnosis, experiment with strategies to improve performance in particular areas of the curriculum, and to develop monitoring procedures to establish the effectiveness of interventions.

Four other implications can be drawn from the analysis presented in this chapter. First, assuming that a pass in Integrated and General Science indicates a minimum level of proficiency in science, the overall pass rates imply that approximately 20 per cent of Form III students and 33 per cent of Form V arts students have not learned enough science or acquired the minimum amount of scientific knowledge and skills required to pass. If the lowest pass grade (P8) is included as falling below the level where scientific thinking is consistently demonstrated (since performance of students obtaining P8 is likely to be made up of successful completion of easier recall items), then over 40 per cent of Integrated Science students and 50 per cent of General Science students would fall below the level where there is evidence of performance involving higher order scientific skills.

Second, the proportion of students who obtained distinctions and credits in the pure sciences is typically between 50 per cent and 70 per cent. Currently this represents between 22,000 and 31,000 students. It is these students who are likely to be most suited to follow further education and training in science. This redraws attention to the question raised in the earlier analysis as to whether these numbers are large enough to meet projected human resource development needs.

Third, the number of rural students who achieve at high levels in science is very small. In General Science, in particular, many rural students perform poorly and increasing numbers are taking this option. Thus any attempt to improve performance in science has to address the learning problems of these low scoring rural students. It is clear that residential/special science school students are high performing and they do have high proportions of rural students. However, these students are a selected group, so direct comparisons in performance with students in other schools are not possible.

Fourth, any attempt at improving science performance should not be made in isolation but should be considered in the context of improving the teaching and learning of related subjects which earlier analysis suggests are part of the problem. Coordination with Mathematics and English quality improvement programmes and curriculum development is therefore desirable.

Part III

Implication of the research for policy and planning

Chapter 9

Clear vision: policy priorities for planning towards the twenty-first century

The Malaysian record of achievement in science education has been considerable. Our research illustrates how rapidly development has taken place and the consistent support given to attempts to improve provision. Notwithstanding this high level of commitment the research has identified various areas in which there are emerging difficulties where there is may be a need to consider new intervention strategies and the development of appropriate policy. The research started with a number of suppositions on which data was required to establish the extent to which they were well founded. We are now in a position to summarise the main findings of our analysis and indicate the directions which future development might usefully take.

9.1 Main findings

First, our data confirm the decline in the number of science stream students. This averaged 6 per cent per year between 1986 and 1990 for Form IV students, resulting in an absolute reduction in numbers of 21 per cent. Over the same period enrolments in upper secondary as a whole increased by 8 per cent. In 1991, there appears to have been a substantial acceleration of this trend. The number of Form IV science stream entrants dropped by a further 21 per cent between 1990 and 1991 as a result of tighter entrance requirements for the science stream and more applications by science-qualified students to join the arts stream. The result was that in 1991 science stream students were 21 per cent of the total number of Form IV and Form V students. These reductions in numbers have not been compensated for by significant increases in enrolments in technical and vocational schools which account for about 2 per cent and 6 per cent of total enrolment respectively. The number of Form IV science students in 1991 (the last year of the old curriculum) fell to the same absolute number as were enrolled in 1977.

The new curriculum arrangements under KBSM, and especially the revised arrangements for options which allow students more choice in the subjects they study mean this situation may be changing. Since this research was conducted a follow-up study has been undertaken (A Study on the Implementation of the KBSM: Elective Choice by Fourth Formers in 1992: EPRD, Ministry of Education) based on a survey in the four States in which this research was conducted. This shows that using Credit 6 as the basic requirement for taking science in Form 4, 45 per cent of the students qualified in 1992. Of these fully 48 per cent 'opted out' of science. The majority of these students did not take any pure science subject or additional science. In 1992, in these states 12,002 students were taking two or three science subjects as electives. If those scoring below credit 6 in science SRP are excluded the adjusted total was 11,543. These qualified students were 23.6 per cent of the total arts and science students or about 20 per cent of the total Form IV students, if vocational students are included. If the basic requirement for taking science is made more stringent, e.g. using Credit 5 or Credit 4 then the percentage who qualified would drop from 45 per cent to 36 per cent or 31 per cent respectively of those reaching the end of Form III. If half of these opt out of science, evolovment of science students in Form IV could fall below 15 per cent.

National statistics from the Schools Division indicate that in 1992, a total of 33,088 students elected for three separate sciences, 5,101 for science and additional science, and 5,225 for a combination of two of the three sciences. There were 194,670 students in arts and science in total with approximately a further 12,500 in vocational schools, giving a grand total of 207,170. All science students (43,414) therefore represented about 21 per cent of the total Form IV students, an improvement over the previous years' Form IV entry where about 18 per cent were science students, and close to the overall ratio for Form IV and V in 1991. It should be emphasized that in 1992, 25 per cent of these science students were taking two pure sciences subjects or a combination of additional science and (core) science (in roughly equal numbers) rather than the full complement of three separate sciences.

We conclude that the decline in science numbers as a proportion of all students stabilised in 1992 as entry criteria were brought back to the same as in 1990 (i.e. Credit 6). Science specialists continue to be concentrated amongst urban students. About one third of those qualified for science have credit 5 and 6 and are therefore likely to find the study of science difficult at higher levels. It is too early to say whether the mild recovery in science enrolments will be sustained. There are implications for the maintenance of balance in the science curriculum from the growing numbers taking two sciences or additional science. There remains a strong case for introducing mechanisms to encourage sustained increases in science enrolments.

Second, our analysis of supply and demand for science school leavers reveals the magnitude of the quantitative imbalance that is emerging. Expansion of further and higher education places for science-qualified school leavers has continued to grow as new enrolments in Form IV science have shrunk. In 1989, we estimate that there were at most about 33,200 science-qualified school leavers at Form V and 4,400 at Upper VI available to apply for higher level courses. Our calculations suggest that at least 26,400 places were available for them. Science students have more places available to them, as a ratio of the number of qualified school leavers, than do those in the arts stream. Our estimates suggest that there are opportunities in science-based areas in further and higher education for about two thirds of those who study SPM science. For arts stream students the places available are closer to one third the number of school leavers at Form V level.

Since all who are qualified will not take higher level courses – a proportion will change specialisations, substantial numbers may enter the labour market or withdraw from it to rear families – supply would seem barely adequate to meet demand. Moreover, the smallest numbers of science stream students were in Form IV in 1991 suggesting that the 1993 output will be even smaller though the number of places available will have increased further by then. Where qualified applicants are in short supply places may be filled by substitution by those who have studied General Science at upper secondary level. Our evidence on the achievement levels of these students suggests they have a much weaker grounding in basic science. Overcoming this through upgrading programmes at higher levels may be a more expensive option than acting to increase the supply of science-qualified leavers. We conclude that this strengthens the case for efforts to increase science enrolments.

Third, data on signals from the labour market support the view of emerging shortages for human resources with a science base. Projected patterns of growth in employment indicate increasing demand at both the professional and sub-professional level. There are almost certainly more job vacancies available for those with science-based qualifications as a ratio of those who possess them, than for other specialisations. Indeed, by far the largest number of reported vacancies for graduates are for engineers. Our interpretation of data on growth in employment in the professional and technical category alone (neglecting the demand from other sectors) suggests planned growth of employment of around 27,000 a year for the next decade for technically qualified staff. This can be compared with current levels of output from Form V and Upper VI suggesting supply is likely to run behind demand.

Under the Second Outline Perspective Plan general economic growth is projected to increase at about 7 per cent for the rest of the decade. With industrialisation, the demand for science and technology-qualified human resources at both professional and sub-professional levels is likely to grow at least as fast as structural changes increase the proportion of scientific and technical workers. Increases of 7 per cent a year in science enrolments would seem a minimum target to aim for to meet projected demand, especially when it is remembered that output from schools will continue to fall until at least 1993 when the 1991 cohort completes Form V. The problem of balancing supply and demand of educational outputs appears partly located at the school level which needs to increase output to feed higher level courses with a science base. It is also important to consider changing the balance in higher level courses in favour of the applied sciences where labour market demand appears strongest but growth has been the slowest, especially at degree level.

Fourth, the analysis of examination performance data confirms that in some areas overall levels of achievement leave room for improvement. Whilst a core of successful schools consistently achieve good results in all subjects, and students in special science schools with selective intakes consistently outperform others, the position in many rural schools and those with small enrolments is less satisfactory. Data on performance in Integrated Science shows that only about 13 per cent of rural schools had a proportion of distinctions above the national mean proportion of 8 per cent. On the other hand, 63 per cent of urban schools scored above this level. In 80 per cent of the rural schools in the sample more than 50 per cent of students only achieved pass grades (P7 and P8). In General Science 36 per cent of rural schools and 70 per cent of urban schools had pass rates above the national mean, and no rural school scored above the national average proportion of distinctions (4 per cent). In about 75 per cent of these rural schools, 75 per cent of candidates failed the subject or achieved pass grades only (P7 and P8). There are similar though smaller differences in pure science subjects with about 30 per cent of rural schools and 70 per cent of urban schools scoring above the national average pass rate (84 per cent). Differences between schools are inevitable for a familiar set of reasons. If the supply of science-qualified school leavers is to be increased it may be most equitable and efficient to direct attention to reductions in disparities in performance between schools.

Though performance may be lower in rural schools our analysis suggests this does not simply mean they are under performing. Our attempts to identify improving and deteriorating schools were complicated by difficulties that arise from changing student populations between Form III, Form V and Form VI; and by the need to clarify the indicators used (overall pass rate? aggregate weighted grade score?). Nevertheless, it should be possible to conceive of planning and monitoring indicators that can distinguish between those schools that make a large difference to the performance of the students they accept and those that do not. It is this, rather than simply overall pass rates, that would identify where interventions were most needed and which schools could provide examples of good practice that might be replicated.

Item analysis provides indications of where difficulties are concentrated for different groups of students. In general, physics-related topics tend to be more difficult for most students. Girls especially appear to perform poorly on questions concerned with electricity. Though rural students generally perform at lower levels on some types of item their performance can be comparable to their urban counterparts suggesting that part of the problem may lie in how questions are presented as well as in how adequately topics are taught. The research demonstrates that powerful insights into areas of difficulty can be generated by item analysis techniques which might provide the basis for intervention to support more effective teaching and learning. The development of KBSM provides opportunities to act on this information.

Fifth, the decline in science stream enrolments is leading to a range of developments. A majority of the schools in our sample had one or no science stream in 1991. Though class sizes in high achieving urban schools were often large, those in rural schools and those with small enrolments often have science class sizes of less than 20 which are at the margin of viability. It is in these schools that the decline in enrolments has been greatest. Our data describe how the conditions for teaching science in these schools may combine together to discourage improvements, participation and achievement. In some cases teacher turnover is relatively high leading to lack of continuity in teaching science. Small schools attract no special support to recognise the diseconomies of scale they suffer from in maintaining a full stock of equipment and materials. Science teachers are isolated and may be more likely to have a teaching load made up with other non-science subjects. Frequency of supervisory visits to support science may be lower than in larger and more accessible schools. Capable rural students, especially girls, may be discouraged from continuing to study science where transfer to distant schools is necessary. For all these reasons a new look at science provision in these schools (which include low performing urban schools) is desirable, starting from the analysis offered in this study.

Sixth, our research data identifies a prospective problem in science teacher deployment. About 70 per cent of those teaching science are trained as science teachers, and about 17 per cent of trained science teachers are teaching other subjects. Overall supply and demand are broadly in balance but inter and intra school deployment patterns result in the under- loading of some science teachers in terms of science teaching periods and the teaching of science by non- science trained teachers. This problem is not currently serious in most schools. However, with a wider range of option choices under KBSM time-tabling will become more complex. Our analysis suggests there are needs to improve the efficiency with which teachers are allocated to schools and to science teaching to ensure that utilisation rates of science trained teachers are high and that almost all students are taught science by those trained to teach the subjects. It may also be important to upgrade the qualification profile of lower secondary teachers since this is where non-graduates are concentrated and to work to improve the quality and motivation of general science teachers who are those least satisfied with being allocated to teaching the subject.

Our projections of the number of science teachers needed confirm that demand will increase over current levels. Expansion of the enrolled cohort in Form IV and V will take place and this will increase demand for science teaching whatever option choices are made. Upgrading certificate teachers (currently over 40 per cent of all those teaching science) to degree status to create an all-graduate profession will also increase demand for training. Science teachers are also being called on to teach new options until those with specialist training become available, e.g. living skills, technical and some vocational options. Annual demand for new science teachers seems likely to fall between 1,000 and 1,500 per year compared to current output which appears to be in the range of 400 to 600 depending on the assumptions made. The numbers will be significantly larger if non-graduates are replaced by graduates and could exceed 2,000 per year.

Our research suggests that a number of curriculum problems remain unsolved. Implementation of new science curricula has not yet succeeded in changing established patterns of teaching and learning to the full extent planned by curriculum developers. Developing intellectual problem-solving strategies is undervalued in much of the teaching we observed, examination orientation strongly influences the learning experience of students in ways which stress the recall of information, practical work often occurs in large groups with limited student participation in design and interpretation of results, students work is not generally characterised by opportunities for original expression. Since there are schools where all these things are achieved in some measure the curriculum implementation problem is how to encourage more widespread adoption of recommended learning and teaching strategies and our research sheds light on steps that might be taken.

The introduction of KBSM extends the curriculum challenge. Students taking two rather than three science subjects are becoming more common. Principles of accounts is becoming a popular choice amongst science students and combinations which include this, or other popular options with science may be a way of encouraging more students to remain specialising in science. Most schools are not large enough to offer all options and elective subjects. Balance should remain an underlying principle in permissible students' choices and there is a need to advise schools on patterns of option choice that respond to student inclinations, provide coherent and balanced science education, and reflect national needs to increase the number of science-qualified school leavers.

9.2 Policy issues and recommendations

Our recommendations fall into five inter-related categories. These are discussed below with a brief commentary on the thinking behind each.

9.2.1 Student flows through science education

Our analysis has enabled us to identify emerging mismatches in the supply and demand for science- qualified school leavers. This leads us to recommend:

- The decline in the numbers of students taking specialist science options should be reversed. This is a priority if the human resource development needs of Vision 2020 are to be met.
- Special attention should continue to be given to create more opportunities for rural students to study science. Science enrolments in rural schools are declining faster than elsewhere notwithstanding the existence of the successful special programmes for selected groups of students.
- Variations in opportunities to study science between states should be gradually reduced to make full use of the nations' human resources.
- Patterns of option choice under KBSM in science subjects should be kept under close review to ensure an adequate supply of science specialists into further education and training and balance in the science curriculum.
- The rate of expansion of opportunities for science education in further and higher education should be matched to levels that can be sustained by school output without reductions in quality.
- Information on opportunities in further and higher education and in the labour market should be made more widely available at school level.

Reversing current trends of declining science specialists in Form IV and Form V requires action on several fronts. Underlying many of our subsequent recommendations is a desire to achieve this. Efforts to improve the quality, relevance and attractiveness of the teaching of science should continue, information of the opportunities and benefits of science-based careers should be widely disseminated, and steps should be taken to improve the management of the delivery of the science curriculum. Taken together these suggestions could form the basis for a strategy to reverse the trends that we observe.

It is clear that science can and is taught effectively in a good number of ordinary government secondary schools. The levels of excellence achieved in special institutions (especially the MARA Junior Science colleges and some residential schools) are impressive. These schools have a special function in Malaysia in preparing a scientific elite and improving access to educationally underprivileged groups. However, the special institutions together enrol less than 4 per cent of all Form V and Form V students. This proportion will decline with the extension of the provision of basic education from 9 to 11 years. Though average levels of achievement at SPM in science subjects in the special institutions are high, the students in them are also highly selected so this is to some extent to be expected. Unit costs are considerably greater in these institutions than in ordinary government schools as a result of the much more favourable staffing ratios and allocation of other resources. There is agreement that a core of schools offering special provision in science plays a valuable role in training the future scientific elite.

However, strategies to improve participation in science and technology-based education in general cannot depend, except at the margin, on substantial expansion of the existing provision in special institutions if only because the cost burden would be severe. Over 95 per cent of the school population will continue to experience science through schools resourced at or near normal government levels. Thus the majority of those who follow professional careers in science, and the overwhelming numbers of those entering middle level careers based on science and technology will remain graduates from normal secondary schools.

This leads us to suggest a dual-pronged strategy to continue support for special institutions on approximately the existing scale, whilst directing much greater efforts to improving the quality and attractiveness of provision in the school system as a whole. Equity and efficiency in human resource development are likely to be best served by this approach which is consistent with the stated ambition, in the Wawasan 2020 initiative, to bring much greater proportions of the population into the mainstream – "No nation can achieve full progress with only half its human resources harnessed".

We therefore favour the development of initiatives targeted on particular needs. These include:

- finding more ways of disseminating good practice in science education in elite institutions to other schools, including possible twinning arrangements of some science schools with others in the locality;
- identifying core schools for additional support for science. A possibility here is to inject additional teachers and resources into the Rancangan Khas programme specifically directed towards improving the participation and performance of rural students;
- offering incentives for disadvantaged urban students and girls to continue to study science;
- providing additional resources to those states where provision is weakest to bring participation and achievement closer to national levels.

The expansion of further and higher education opportunities has developed in ways which may not fully reflect human resource requirements. Specifically, the ratio of certificate:diploma:degree courses in the science and technical field has changed from 17:34:49 in 1985 to 15:29:56 in 1990. The predominance of opportunities at degree level needs to be considered given the shift towards manufacturing and the resultant demand for middle level technical human resources. In addition, increased concentration in the period of the Fifth Malaysian Plan on pure science (increased by 51 per cent) rather than applied sciences (increased by 27 per cent) has implications for the flow of school leavers and may influence option choice in Form IV. The problems of balancing participation in science at school level with national needs cannot be separated from developments in further and higher education. It would seem there is a need to monitor enrolment growth at higher levels to ensure that these follow planned targets for human resource development more closely.

A specific suggestion is that EPRD should coordinate systematic monitoring and research on option choice as a matter of urgency. How students choose under the KBSM has many implications for educational planning (for teacher training, teacher deployment, the opportunities to study science for different groups, the flows of students with science qualifications, etc.). The pattern of enrolments for different options under KBSM system will take some time to stabilize. However, the choices that students make now will determine the balance between supply and demand for science-qualified leavers for years to come.

The monitoring system of option choice that is needed could take several forms. Most simply, a nationally representative sample of schools could be selected and data gathered to establish what choices have been made. This should be initiated as soon as feasible and be part of an annual exercise until the KBSM system has matured. Analysis of choice patterns will enable changes in the demand for different subjects to be identified at the earliest possible time. The data could provide the basis for guidance on the framework within which option choice should be permitted; it would allow the fine tuning of teacher deployment to reflect demand for the teaching of different subjects; and it could identify curriculum issues that arise. It would also provide the data needed to decide policy design to reconcile the consequences of individual option choice with the overall pattern of demand for school leavers projected by the Sixth Malaysia Plan and the OPP2 as being in the national interest. Since data was collected for this report a preliminary study on option choice has been completed.

The research illustrates a measure of confusion and lack of information about changing patterns of opportunity in higher and further education and in the labour market. It is not clear that the information on which students make subject choices and on which counselling is based accurately reflects the current situation. There appear to be greater opportunities to continue studying at higher levels in science-related subjects than is commonly appreciated. Projections of employment needs under OPP2 suggest substantial increases in demand for science-based employment at both the professional and sub-professional levels. The numbers studying science seem to have been influenced by lack of accurate information on supply and demand for students specialising in science subjects. There is therefore a need to disseminate career choice information more widely at the school level. One method is to publicise application/entrant ratios to courses of further study which would illustrate where demand is greatest and where competition is most fierce. Another is to provide counselling staff with more information on areas where employment generation is most rapid so that they can moderate advice based on the personal preferences of students with data on where opportunities are most likely to be freely available. It is clearly important that counselling staff are aware of national plan priorities and see it as part of their job to help these come into being.

We therefore see room for initiatives to:

- produce and disseminate accurate information on opportunities in further and higher education and the labour market which are linked to national development aspirations;
- strengthen the role of counselling teachers and senior science teachers in advising students about careers in science;
- provide guidance to principals on patterns of option choice that should be encouraged and discouraged and indications of criteria that are appropriate to apply as entry conditions for the study of different subjects at Form IV.

9.2.2 The organisation, management and support for science education

Changes are being introduced into the organisation and support for science education in parallel with the implementation of the new secondary curriculum, KBSM. Our recommendations here are:

- responsibilities at school level for the development of science teaching and the improvement in achievement levels of students should be clearly defined and located with particular members of staff;
- inspection, supervision and support systems for the development of science education should be strengthened;
- the resource allocation system for science in rural schools with small science stream enrolments requires special attention.

Though science and technology are prominent priority areas in national development plans, science is not accorded special priority by most school administrations. Very few school principals have special competencies in science and are therefore disadvantaged in directly supporting the development of science in their schools. Heads of science departments rarely receive training and their responsibilities do not appear to be clearly defined. Under the proposals for the reorganisation of schools senior posts are to be created that include one with special responsibility for science and mathematics. This is a very positive step. The information and training needs of senior science teachers need careful consideration. A first step would be to initiate in-service training and staff development courses alongside small scale research into the role of senior science teachers. It is particularly important that principals are encouraged to support these developments. Consideration might also be given to incentives to recognise the contribution made by particularly effective science teachers and those working in unattractive postings in both rural and urban areas.

Specific suggestions are therefore:

- allocating responsibility and authority to Senior Science Teachers who should have clearly defined job descriptions outlining their responsibilities for developing science education in schools as a whole;
- ensuring that Senior Science Teachers are trained in management, organisational skills and staff development and are encouraged to develop medium-term development plans;
- special emphasis on support for and delegation to Senior Science Teachers in the training of principals.

The frequency of supervision, deployment of state science curriculum officers, and sources of professional advice for science teachers are limited in their effectiveness by their scarcity. Much could be done in this area which could have considerable benefits at relatively low cost. Specifically, to be influential the deployment of advisory staff for the development of science at the state level should be linked to the number of schools supported. The current system, allocating the same number of state curriculum officers independent of the size of the state, dilutes support available in large states. Support and advice for the development of science education from outside the school will always be in short supply. Strategies must therefore be supported which stretch a modest resource towards areas of greatest need and multiply its effectiveness. This may be achieved by encouraging the development of local networks of schools for mutual support most obviously through encouraging the sharing of experience between science teachers and focusing on them as the most promising change agents.

We therefore suggest:

- reducing the disparities in the support ratio of supervisory and monitoring staff between states;
- providing modest resources to support the development of local networks;
- inviting district and state level support staff to co-ordinate research and intervention projects to improve the quality of science teaching in selected schools where the needs for improvement are greatest.

The special conditions of rural and small schools invite systematic as opposed to ad hoc arrangements. The standard resource allocation pattern makes little allowance for varying conditions. There are economies of scale in larger schools (equipment may be more intensively used, maintenance arrangements can be more efficient, library stock may be greater). Without compensatory arrangements the quality of science provision in small and rural schools will be inferior at the same levels of unit cost. Capitation arrangements should recognize this by allocating a greater amount per student to schools with designated characteristics.

The resource base for the teaching of science is generally adequate and physical resources are fairly evenly distributed between schools. Nevertheless, there are wide differences in the performance of schools and different groups of students which do not appear to arise solely from differences in the quality of students entering different schools. This may be partly attributed to variations in the quality of the management of resources for teaching and learning. Management practices vary widely and these affect the climate in which learning takes place, the motivation of staff and students, the amount of time given to purposeful learning, and the extent to which curriculum goals are achieved.

The case study data provides insight into the management practices that seem most closely related to the quality of science education. They point to areas of effective and ineffective practices which could provide the basis for training exercises and could be used to catalyse staff development work to identify critical areas where more training and support may be needed. The individual school case study reports are themselves a valuable resource for training activities.

The central management issue is not so much what are the characteristics of schools with high performing science students, but how can changes in management practices improve schools which perform poorly in science? It is in these schools that the problems lie. One way to explore this is to undertake small scale research and development exercises on school management targeted on science provision. The methods of action research suggest themselves. These encourage staff to analyze their own problems and to develop and try out their own solutions in discussion with other teachers. These solutions can be tested and reviewed to arrive at new and more effective practices. It is crucial to appreciate that action research does not mean research first and action later. It is concerned with the development of teachers as reflective practitioners who continuously seek to improve their own practice. It is a form of staff self-development. Teachers' professionality can be enhanced by involvement in systematic attempts to design improved teaching and learning, and change the organisational arrangements that provide support. These methods can be employed with officers at the district and state level, as well as with senior school staff. They allow the development of a research as well as administrative culture in the management of schools.

9.2.3 Monitoring student achievement in science

There are a number of steps that could be taken to refine the system for monitoring school performance in science, deepen understanding of the causes of low achievement, and design interventions to improve examination results. We therefore recommend:

- the development of more sensitive school performance indicators to provide widely understood and readily available information to monitor performance and identify schools which are under performing.
- diagnostic item analysis at national level on samples created to examine the performance differences between different groups of students.
- more detailed feedback of performance on science examinations to schools.

- Support for the development of more effective performance monitoring within schools

The research has illustrated the strengths and weaknesses of several different approaches to monitoring performance in science examinations. Most obviously it draws attention to the limitations of the use of pass rates alone as an indicator. This indicator does not account for changes in the distribution of grades (distinction, credit, pass) achieved by students in different schools. Thus in the survey we have identified schools where the overall pass rates have improved whilst the percentage of distinctions and credits has declined. If judgements are made on school performance on the basis of pass rates alone this important information is lost. Clearly a more comprehensive approach is desirable.

We have used a weighting system (distinction 3 points, credit 2 points and pass 1 point) to produce an aggregate score that is more sensitive to a change in distribution of grades. This indicator produces a score for each examination subject which helps identify improvements in the number of credits and distinctions gained. This provides an additional basis on which school performance can be compared which captures some aspects of changes in the distribution of grades. An example makes the point.

	Per cent Dist. (1,2)	Grade Per cent Credit (3,4,5,6)	Per cent Pass (7,8)	Fail (9)	Overall pass rate	Weighted score
School A	4	25	65	6	94	127
School B	15	35	35	15	85	150
School C	13	41	40	6	94	161

On the basis of overall pass rate schools A and C are the same. However, the distribution of grades is very different. School C has 54 per cent of students gaining credits or distinctions, whereas school A only has 29 per cent scoring at this level. This is indicated by the weighted score which is greater for School C (161) than for School A (127). School B appears to be lower performing than School A on the basis of overall pass rate (85 per cent). However, its percentage of distinctions and credits (50 per cent) is also higher than school A's. The weighted score draws attention to this since it is greater for school B than for school A (150 rather than 127).

A combination of the two methods of indicating school performance (pass rates and weighted scores) would seem to provide a better way of assessing school performance than either method used alone. More complex indicators of greater statistical elegance might be desirable but would not be widely understood at the school level. Using the two indicators suggested, rather than pass rates alone, could then assist in drawing attention to those schools where overall performance was sharply deteriorating or improving, and where the distribution of the grades awarded was changing in ways which invited concern.

It is a central concern of planning to establish which schools have been improving their performance and which have deteriorated. Since scores are not standardised from year to year the appropriate point of comparison is not changes in the annual pass rate (or weighted score) but rather a comparison with the mean of a comparable group of schools (e.g. in the same State) for each year. It is changes in the variation from the mean that indicate relative improvement or deterioration. Using this kind of definition it is important to remember that not all schools can improve in terms of the average – in general half the schools will perform below average and half above. Thus, if the concern is with standards of performance across the school system as a whole, rather than relative improvement and deterioration, other techniques for monitoring standards must be used. These must control for variations in the difficulty of examinations from year to year, and changes in the population of students taking them. There are established methods for exploring this question which might be employed by the Examination Syndicate.

None of these methods of monitoring school performance takes into account the quality of the students entering the school. Using indicators uncorrected for variation in the background of students has limitations. This can be simply illustrated. Students entering a school in a high class residential area in Kuala Lumpur will have enjoyed educational advantages from their family background. By contrast students entering a remote rural school in Terengganu will be relatively deprived. Several other studies in Malaysia have demonstrated the correlation that exists between academic performance and home background. An SRP pass rate of 95 per cent in the school in Kuala Lumpur does not demonstrate on its own that it is a good school. Similarly an SRP pass rate of 75 per cent in the Terengganu does not demonstrate that it is a poor school. The school in Terengganu may have improved the performance of students through effective teaching and learning more than the school in Kuala Lumpur. The students simply started at different levels of achievement.

It is possible to conceive of a 'value added' indicator that does include a correction for the entry characteristics of students. This would assess how much the school has 'added' to the performance of students through the teaching and learning that has taken place. The construction of such an indicator depends on research to establish just how important home background and other non-school factors are in determining achievement. Judgements would also have to be made about the interaction of school and non-school factors. Existing data is sufficient to provide a basis for a modelling exercise to establish just how such an indicator might be developed. The UPSR (Primary School Assessment Examination) entry scores of students are known and could be used as the basis for general classification of schools in terms of the academic achievement on entry. This could then be used as a control to moderate indicators of performance at SRP and SPM level, and to identify schools that did make a lot of difference to the performance of their students and those that did not. We cannot pursue this option further in this report, except to suggest its consideration as a research study.

We note three other planning implications for the development of performance indicators. First, there appears to be a need to improve feedback of performance information to schools through the supervisory system. Supervisory staff at district and state level lack information on the performance of schools in science at any but the most aggregate level of overall pass rate in different subjects. Generally there are no convenient mechanisms to identify simply schools where problems in performance are particularly serious except at the level of overall pass rates. It is possible to design software to monitor school performance at a national level that would identify rapidly schools within each state/district that are under performing or deteriorating in science. This could be used to target inspection and special interventions to support remedial measures.

Second, much could be done at the school level through the development of more adequate school-based analysis of performance. In relatively few schools does there seem any systematic procedure to analyze the performance of students and use this as a basis for teaching interventions to overcome areas of weakness. It is not clear whose responsibility this might be. In general it is the principal, but in practice it is the senior science teacher who could play this role since most principals are not science trained. Currently science Panitias do not seem to devote much attention to this area. There is an opportunity to incorporate school-based performance monitoring into the responsibilities of senior science teachers in a practicable way which is not too time consuming or complex to be unworkable. Simple procedures are needed that can be disseminated through in-service courses and written material describing how to do the analysis.

Third, the analysis of performance we have conducted on scripts from different types of schools illustrates how differences in performance between urban and rural, high and low performing, and girls and boys schools can be identified. More particularly it shows which questions are responsible for most of the differences in performance between groups. The techniques used identify particular questions (and hence areas of the curriculum) where students achievement is weakest; they locate the questions where the largest differences in performance arise between different groups; and they are cheap and easy to use. They address issues of central concern to policy-makers and can replace speculation, intuition and casual empiricism by data on what the differences actually are. They can provide the basis for focused interventions, supervision and support in those areas of the curriculum where it is most needed.

The logical development of the examination analysis in this research is to establish a follow up study to refine the techniques used, generate data from a sample of schools, and design teaching and learning interventions to improve performance and reduce differences between types of schools and students. The effectiveness of these interventions could then be evaluated with a view to more widespread use.

9.2.4 Curriculum issues

This study has not addressed curriculum issues directly. The analysis does however suggest a number of areas that should be addressed. These are summarised in the following recommendations:

- The Curriculum Development Centre should be invited to follow up the specific areas of learning and teaching difficulties identified in this study in science and related mathematics curricula and develop appropriate enrichment material.
- More science reference material should be developed in Bahasa Melayu.
- The role of practical work should be reconsidered in view of current patterns of use and costs.
- The General Science curriculum should be reviewed to improve its relevance and the levels of achievement of students who study the subject.
- The curriculum implications of free option choice for science subjects under KBSM need careful monitoring to ensure that students receive a balanced and appropriate exposure to science which reconciles student preferences with national human resource development needs.

Further curriculum development of the various science courses is desirable. There is, however, no evidence that the basic form of the curricula is unsatisfactory. Rather there are indications of a number of areas in which enrichment, review, revision, and changes on the margin could pay dividends. The problems seem to lie predominantly in the implementation and management of effective teaching and learning and with enrichment to help overcome specific areas of difficulty. From our data it is clear that the national curriculum is delivered in different ways in different types of schools. Where this is the result of professional decisions to adapt implementation to the needs of particular students this is to be applauded. However, our data seem to indicate that this is not generally the case. More often variations in the quality of implementation are a result of non-curricula factors, e.g. convenience, the characteristics of teachers available, the pressure to conform to the demand of public examinations and concentrate on the restricted range of outcomes they assess. This suggests that curriculum developers need to recognise these reasons why implementation is not always faithful to the original design and develop materials accordingly. Thus, for example, our research shows that practical work is most commonly conducted in groups of five or six. Much practical activity is designed in ways which seem to imply group sizes of two or three if all students are to be involved. Similarly, the pattern of use of textbooks and work books we have identified in the case studies gives food for thought about officially provided materials. The question is to what extent should the curriculum be changed to reflect preferred patterns of use (in the examples above large practical groups and heavy use of workbooks). Or, alternatively, what additional conditions would need to exist if intended patterns of use were to become more widespread?

Analysis of areas of learning difficulty and poor examination performance suggests that enrichment material (and advice for teachers) could be developed especially for selected topics. In science this applies particularly to some physics related topics at all levels. A review of the mathematical demands of science courses, and a linking of science curricula to the sequencing of the teaching of mathematics, would seem desirable since this is also an area of general difficulty. Language, and particularly the problems connected with lack of facility in English which limits access to reference books at higher levels warrants special consideration as does the provision of more reference material in Bahasa Melayu.

A further observation is needed on the role of practical work and the provision of practical facilities. The latter are expensive and in a good number of cases not fully utilised. This arises partly from falling enrolments, from inefficient management of resources, and in the case of General Science a lack of commitment to its value. As noted above practical work is most commonly undertaken in large groups, though there is little indication that practical tasks have been designed with large groups in mind. An alternative method of exposing children to empirical data – teacher demonstrations – is employed infrequently, though it is usually cheaper and likely to be easier to manage. In most schools there was very limited evidence that practical work was used to develop and reinforce intellectual skills despite its high costs. This suggests either that the curriculum rationale for practical work be reconsidered and the demands made by it on resources be reduced, or that new efforts are needed to ensure that practical work is used for its intended purposes to provide both concrete learning experiences and opportunities for scientific thinking more frequently. A pilot project should be considered to develop techniques for the more effective use of practical work to teach intellectual skills based in schools where this is not common practice.

The one subject that may be an exception to the general view that curriculum development might best be directed towards enrichment rather than redesign is General Science in upper secondary schools. Our research suggests that achievement in this subject is often poor, teaching is frequently classroom-based with no practical work, and many general science teachers are not strongly committed to the subject. It is, however, the most frequently taken science subject (by over 75 per cent of students) and the last experience most students have of science. It is these students who will form an increasing proportion of the entrants to the sub-professional categories of employment and to many diploma and certificate courses if the swing away from science continues. It is important, therefore, that the curriculum is appropriate to the needs of the students who follow it and that it is taught effectively. We would therefore suggest a special review of general science, covering both curriculum issues and patterns of performance, with a view to appropriate redesign.

The last observation on curriculum issues has already been mentioned above and it may prove the most important. Under KBSM students can exercise considerable choice over the science subjects they study. Greater choice may exacerbate the swing away from science in rural schools and those with small enrolments and result in unbalanced combinations of subjects. To reduce these possibilities modifications may be needed to the combinations of subjects permitted for public examinations and curriculum development orientated towards making science subjects more attractive and relevant. With less time available (four rather than five periods per science subject) there may be implications for Form VI level curricula. All these factors indicate the need for closer coordination between the different parts of the Ministry responsible for different aspects of science education development. These include the Educational Planning and Research Division, the Examination Syndicate, Schools Division, the Inspectorate and the Curriculum Centre. It may be better to convene task groups for specific purposes under the leadership of the Central Curriculum Committee than to establish many inter-departmental liaison committees.

Coordination with other Ministries is also desirable, e.g. the Ministry of Science and Technology and of Human Resources.

9.2.5 The deployment and training of teachers

Redressing the balance in participation, improving the output of science-qualified school leavers, and enhancing the quality of science education all depend directly on a supply of adequately trained, supported and motivated science teachers. Our analysis leads us to recommend:

- teacher deployment at the inter and intra school level requires reexamination to ensure that trained science teachers are used efficiently and that as much science as possible is taught by trained science teachers;
- the projections of science teacher supply and demand we have made should be refined and undertaken annually.
- selective expansion of science teacher training is required to ensure that a balance is maintained in the supply and demand for science teachers;
- Science teachers at lower secondary level, and particularly those teaching the lower Forms and those teaching General Science, should have their professional qualifications upgraded;
- an appropriate balance needs to be struck in initial and in-service training between innovatory methods for science teaching and those which have demonstrated their effectiveness over time.

We have shown that there is an approximate balance between the number of science teachers in schools and the number needed. There does, however, seem to be an unevenness in deployment between schools, and within schools. This results in imbalances in the number of qualified science teachers per student in different schools, the extent to which qualified science teachers are teaching science within different schools, and the time-table load in science subjects of science teachers. Part of the reason for this appears to be the absence of detailed data on science teacher requirements and deployment in easily accessible form, particularly at the state and district level where decisions are made on posting. This makes it difficult to solve the problems systematically and increase the efficiency with which the current stock of science teachers are utilised.

The development of Educational Management and Information Systems (EMIS) provides an opportunity to include data on school staffing which can be easily accessed at the time when deployments are being considered as noted above. To achieve this a clear view has to be taken on the definition of those qualified to teach science. The current situation appears less than satisfactory since several assumptions appear to have been made in projections that remain untested (e.g. that teachers trained in mathematics can teach science effectively, and that substitution between science teachers – as with biologists teaching physics – is not problematic). The definition of who can and should teach general science needs further consideration. In addition, actual time-tabling decisions are made at the school level and there is some evidence that efficient utilisation of trained science teachers is not always achieved. There is therefore scope to provide more guidance to principals and senior assistants on the efficient time-tabling of teachers trained in different subjects.

Our projections of science teacher supply and demand draw attention to a substantial increase in the numbers of science teachers that need to be trained over the next ten years. Lower secondary science teachers and those of General Science are most under- qualified, and it is here that more trained teachers might be expected to result in the greatest achievement gains for students. What precisely the additional training needs are depends on a number of assumptions detailed in *Chapter 7*. Between 1990 and 2000 between 10,000 and 16,600 new science teachers are likely to be needed. If non graduate teachers are to be replaced or upgraded this will increase demand substantially. This will require an expansion of teacher training to produce between two and four times as many science teachers annually as are currently produced. Projection exercises of the kind we have undertaken should be repeated at regular intervals to take account of new developments and tune growth in output to demand.

Since we have identified the implementation of the different science curriculum as a more central problem than the curriculum itself it is clear that effective initial and in-service training is critical. On the limited evidence available we are inclined to favour closer relationships between initial training institutions and schools, with more encouragement for the involvement of experienced and effective science teachers based in schools in the training process. This offers the prospect of effective induction of teacher trainees into the profession of science teaching based on needs identified by practising teachers, and has staff development benefits for those involved. It will encourage emphasis in training on teaching methods of tested value rather than of theoretical interest alone.

Our evidence on the effectiveness of in-service training is paradoxical. Despite high reported levels of satisfaction from teachers in the survey, our case study data suggests that not all teachers have such favourable perceptions and that teaching methods in science often seem resistant to change in the directions advocated by such in-service courses. This is an area for further research before embarking on any general expansion of what are already commendably high levels of in-service effort, at least if judged by the numbers of science teachers participating. One promising avenue is to examine how to direct the attention of science Panitias towards staff development and school based in-service work since most appear preoccupied with administrative concerns. There is scope here to encourage more professional reflection and small scale action research by teachers on their own practice. The potential of this could be explored by devising schemes to provide modest amounts of time (e.g. reduction in teaching loads) to teachers who wish to undertake development work for their science departments. Where such efforts are successful recognition should be given by creating opportunities for wider dissemination amongst the community of science teachers. This could also be linked to the problem of upgrading existing certificate teachers to graduate status in line with current policy. The needs appear greatest for this amongst lower secondary teachers and those of General Science.

Some specific suggestions include:

(i) clarifying the appropriate teacher training qualifications for different science curricula;
(ii) involving Senior Science Teachers more directly in the initial training of teachers;
(iii) encouraging Senior Science Teachers to take the lead in professionalising the activities of Science Panitia and supporting research and reflection on practice at the school level;
(iv) strengthening programmes to upgrade under-qualified science teachers.

9.3 Reflections

This research has explored the development, achievements, plans for science education in Malaysia as the twenty-first century approaches. Undertaking this research involved the development of a number of planning, monitoring and evaluation procedures and the integration of data from the secondary school system, further and higher education, labour market projections, and national policy documents. To our knowledge this had not been attempted before in relation to science education. We have employed a battery of techniques to collect, collate and interpret information. These include those familiar to staff of EPRD, e.g. survey analysis, interrogation of school census data, enrolment and teacher supply projection techniques, and those that are less familiar, e.g. condensed case study techniques, methods of performance analysis, indicators of the utilisation of resources for science in schools. Taken together these have created a unique empirical base for policy analysis. This highlights areas in which the experience has been impressive, and those where expectations have not matched reality. It is appropriate to conclude by drawing attention to some strategic issues which lie behind much of the analysis offered. There are three of these.

First, though the study has focused on secondary science this should not be taken to reflect complacency about other levels. Science education is a continuous experience that starts in a relatively unstructured way when young children first begin to explore the world they have entered through their senses. Much can and should be done in primary schools to help to develop conceptual frameworks through which to interpret experiences of the natural world. This is both because the foundation built at this level is the bedrock on which more systematic knowledge and understanding of science may be built at later stages, and because learning about science is itself a method through which cognitive development can be encouraged. Thus, there is a need to keep curricula provision at this level under review if secondary science is to be planned on the basis of realistic assumptions about how much science, of which kinds, students have acquired in the primary grades.

Second, permeating the explanation of the swing away from science that we have identified is the inference that increasing numbers of students have a negative attitude to the study of science and that this probably strengthens the older the students are. Though there is no hard evidence on this it seems that the climate of opinion that influences the choices students make and the motivation they bring with them to study science has changed over the last two decades. There may be many reasons. The Malaysian recession in the late 1980s brought the vision of unemployed science graduates to the notice of the public for the first time. The perception of science as difficult may have become more entrenched as greater proportions of the age group began to study science. Economic diversification and growth have created a much broader range of job opportunities than existed a decade ago, some of which are more remunerative than jobs requiring qualifications in science and technology.

All of these possible explanations can be contradicted. Currently labour market demand for those with science and technology qualifications appears buoyant and set to continue to grow especially for those with applied science backgrounds at all levels. Science is not, in fact, more difficult than other subjects if judged by the distribution of examination grades – English and Mathematics tend to be more difficult. Though there is a great deal of interest in courses of study that lead to highly paid occupations (e.g. accountancy) that are not science-based, most of these professions do not preclude science students from entering them and some actively encourage applications from science students. Engineers are in demand and are highly paid. National development policy clearly implies that science and technology are not in themselves responsible for cultural dislocation and environmental degradation. They are seen as tools to assist in balanced development of Malaysian society and the preservation of its culture in the modern world.

The point here is that the quantitative and qualitative problems we have identified in planning future provision in science cannot be solved without generally held positive attitudes to the subject and to the value of studying it. This is a challenge to science educators, and to Malaysians who wish to 'make science and technology integral components of socio-economic planning and development and promote a science and technology culture compatible with the process of building a modern industrial economy'. It is clear that simply creating more opportunities to study science will not succeed in overcoming the problems we identify. Without attention to improving motivation and quality the consequence would be a reduction in standards as greater numbers participated. Thus improved access should be accompanied by initiatives on a broader front which seek to encourage demand for places studying science, improve awareness of the opportunities that this creates, and maintain and improve standards of entry and achievement. Central to this are attitudinal changes that value technological proficiency and innovation and which recognises the positive benefits for individuals and for Malaysian society of studying science.

Finally, at the heart of a number of the planning issues identified is a dilemma. The choice is between using planning to monitor the effects of demand generated by individual decisions, and using planning to determine the pattern of educational opportunity that is available to serve national needs for human resource development. These two extremes can be conveniently described as responsive and indicative planning. These both require some further explanation.

Responsive planning seeks to provide the earliest possible insights into the patterns of choice that are being made. Steps can then be taken to meet the demand for places generated by individual decisions. The main problem is that there is no necessary correlation between the choices made and national human resource development needs since the former are influenced by an individual judgement of private benefits and the latter by collective judgements of public benefits. This approach is often modified in practice by using information on choice to develop incentives to influence the pattern of individual decision-making towards publicly desired outcomes. Thus, considering science option choice as an illustrative example, if the number of science students was thought too low entry could be made easier and the quality of teaching enhanced or more scholarships offered.

Indicative planning, on the other hand, seeks to purposively constrain choice so that the results are consistent with planned human resource development needs. Thus, for example, limits could be established on the ratio of students taking science- and arts- based courses and the number of places made available determined on this basis, thus ensuring particular numbers of science students. The difficulties here include those of making accurate projections of national human resource development needs and of ensuring that places are taken up by students of an acceptable quality.

In some respects (especially enrolments in science), planning for science education in Malaysia seems to have moved away from indicative planning (where science stream numbers were controlled and students were allocated centrally to the places available) to a more responsive planning approach where student choice is given greater weight. This seems less true in other areas (e.g. finance, curriculum) where central control has been maintained.

An acceptable compromise needs to be found between the legitimate aspirations of individuals and the responsibilities of government to take a view of the collective interest. Allowing the "market" full autonomy may have some attractions if the conditions of free markets can be approximated (e.g. unconstrained choice, equal access to information). These conditions are difficult to meet. Most students cannot, in practice, choose the school they attend, schools are themselves limited in the options they can provide, information is unevenly available, and other factors (e.g. family circumstances) may determine choice for some and not for others. Even if conditions are acceptably close to a free market there will be time lags that can have some quite serious consequences. Educational investment cycles (e.g. in building science-teaching facilities) are medium-term projects. Market signals can be quite unstable, swinging from surplus to deficit rapidly.

Thus, a strategic issue is to decide to what extent the 'market' in science education can and should be managed and what policy instruments can be used for this purpose. It seems likely that such an approach is needed, at least on the enrolment side of science education planning, if sufficient flows of suitable quality school leavers are to be maintained. Expansion in science and technology based further and higher education will otherwise be constrained by a shortage of suitably qualified applicants, and the human resource development needs identified in OPP2 may become difficult to meet. Without selective intervention it may also be the case that the special needs of groups who are educationally underprivileged in science education (e.g. rural students) will suffer relative neglect and differences between the groups will grow.

9.4 Conclusion

This report has identified key problems and issues in secondary science education as they affect Malaysia's human resource development strategy towards 2020. The priorities we have identified are to:

(i) reverse the swing away from the study of science subjects at secondary school level;

(ii) enhance the quality of science education in the general school system to ensure that future human resource demands at all levels can be met;
(iii) improve the efficiency and equity with which resources are allocated to science education at school level and adopt measures to increase the participation of rural students in science;
(iv) use the analysis of performance in science subjects to improve achievement and reduce disparities between groups of students;
(v) monitor option choice for science subjects to maintain a balance between individual preferences and national needs;
(vi) identify training needs in sufficient time to avoid shortages in the number of qualified science teachers;
(vii) introduce a number of planning procedures to improve the quality of decision-making for science education.

The prospects of achieving the goals spelt out in recent policy statements for Malaysia to become a fully developed country by 2020 are good. They depend on the full utilisation of the nation's human resources in science and technology more than in most other areas. It is, therefore, pivotal that the foundation for this, the education of young Malaysians in science at school level, is made secure and that science education is inventively and efficiently planned.

This is partly a technical problem – ensuring that resources of sufficient magnitude and quality are available as and when needed. It is also a human issue where an imaginative balance has to be struck between technological and economic realities and the values and aspirations which define a developed Malaysian society. The agenda presented by this report provides a starting point to address this challenge.

Glossary of acronyms

EPRD	Educational Planning and Research Division, Ministry of Education
EPU	Economic Planning Unit of the Prime Minister's Department
FIT	Federal Institute of Technology
FMP	Fifth Malaysia Plan
FRS	Fully Residential Schools
IKM	Institut Kemahiran MARA (MARA Vocational Institute)
ITM	Institut Technology MARA
JPM	Jabatan Perdana Menteri (Prime Minister's Department)
KBSR	Kurikulum Baru Sekolah Rendah (The New Primary School Curriculum)
KBSM	Kurikulum Bersepadu Sekolah Menengah (The Integrated Secondary School Curriculum)
MARA	Majlis Amanah Rakyat (Council of Trust for Indigenous People)
MJSC	MARA Junior Science College
MOE	Ministry of Education
NDP	National Development Policy
NEP	The New Economic Policy
OPP2	The Second Outline Perspective Plan
PKB	Politeknik Kota Bharu
PKS	Politeknik Kuching, Sarawak
PMAS	Politeknik Sultan Abdul Halim Muadzam Shah
PPD	Politeknik Port Dickson
POLISAS	Politeknik Sultan Haji Ahmad Shah

PUO	Politeknik Ungku Omar
SMP	Sixth Malaysian Plan
SPM	Sijil Pelajaran Malaysia (Malaysian Certificate of Education)
SPMV	Sijil Pelajaran Malaysia Vokasional (The Malaysian Certificate of Education (Vocational))
SRP	Sijil Rendah Pelajaran (The Lower Certificate of Education)
STPM	Sijil Tinggi Pelajaran Malaysia (The Higher School Certificate)
TAR College	Tunku Abdul Rahman College
UIA	Universiti Islam Antarabangsa (The International Islamic University)
UKM	Universiti Kebangsaan Malaysia (The National University of Malaysia)
UM	University of Malaya
UPM	Universiti Pertanian Malaysia (The Agricultural University of Malaysia)
UPSR	Ujian Penilaian Sekolah rendah (Primary School Assessment Test)
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
UUM	Universiti Utara Malaysia (Northern University of Malaysia)

Glossary of terms

1. Mara

Majlis Amanah Rakyat or MARA is a statutory body under the Ministry of National and Rural Development. It was established with the objective of providing motivation, guidance as well as training opportunities to Bumiputras to enable them to participate actively in commerce and training.

2. The Rukunegara (national ideology)

The Rukunegara, proclaimed in 1970, is an important milestone in the history of educational development in Malaysia. The important aims underlying the Rukunegara are the establishment/achievement of:

(i) A united nation of a plural society;
(ii) A democratic society through a constitutionally elected parliament;
(iii) A just society of equal opportunities for all;
(iv) A liberal society of diverse cultural traditions; and
(v) A progressive society oriented towards science and modern technology.

3. The new economic policy (NEP)

The NEP, launched in 1970, was designed to bring about a more equitable distribution of wealth between the different races as well as groups in the various strata of society. It had the overriding objective of fostering national unity as well as nation-building through a two-pronged strategy:

(i) the eradication of poverty irrespective of race;
(ii) the restructuring of Malaysian society to reduce and gradually eliminate identification of race with economic function and geographical location.

4. The industrial masterplan (IMP)

The IMP, published in 1986, is the first masterplan of its kind in Malaysia's history. It documents an analysis of Malaysia's industrial heritage and proposes industrial policies to improve the Malaysian industry.

5. Wawasan 2020 (Vision 2020)

This represents a vision, first put forward by the Prime Minister in a working paper to the Malaysian Business Council in 1991. It is a vision to turn Malaysia into a fully developed nation by the year 2020, a nation which is fully developed in all dimensions: economic, political, social, spiritual, psychological and cultural.

6. The second outline perspective plan (OPP2)

The First Outline Perspective Plan (OPP1) outlined medium- and long-term targets for the NEP for the period 1971–1990. During this period four national development plans, i.e. from the Second to the Fifth Malaysia Plans were carried out. The Second Outline Perpective Plan (OPP2) covers the period 1991 to 2000 and has been formulated on a policy called the New Development Policy (NDP). It provides a broader framework for achieving the objectives of the NEP and also sets the agenda for Malaysia to attain the status of a fully developed nation by the year 2020.

7. Group I:II:III pyramid ratio

Group I refers to all schemes of service requiring university degrees. Group II refers to those which require Diplomas and Higher School Certificate qualifications while Group III refers to services that require qualifications at the Malaysian Certificate of Education level or lower. Thus the Group I:II:III pyramid refers to the relative numbers of workers in the various schemes of service.

8. Grade A schools

These are secondary schools with one of the following characteristics:

(i) classes up to Form VI level;
(ii) classes up to Form V level with a school enrolment of not less than 1,500;
(iii) classes up to Form V level with a school enrolment of less than 1,200 but with hostel facilities for not less than 250 pupils.

9. Grade B schools

All secondary schools which are not Grade A schools.

10. Controlled schools

Schools where the enrolment is under the control of the State Education Department.

11. Panitia

Panitias exist for each subject and are panels made up of teachers teaching a particular subject in the school.

Appendix I

Technical notes on data collection

The data collection methods, sampling procedures, and administrative arrangements for the five different components of the research are described below.

1. The baseline study and the analysis of the flows of students from the school system

The Baseline Study and the analysis of Flows of Students from the School System involved two main data collection methods. These were:

(a) documentary analysis;
(b) interviews.

Documents analysed for the Baseline Study included reports of the various Divisions of the Ministry of Education and interrogation of the Ministry data bases on enrolment, teachers, resources, etc. In addition, interviews were conducted with a range of people that included a selection of State Science Supervisors, officers from the Schools Division, the Curriculum Centre, and the Inspectorate. The Baseline Study was then constructed making extensive use of statistical data to provide a profile of science education in the schools.

1.1.1 Documentary analysis was also used for the collection of data on the flows of students into courses at higher levels and into the labour market. Documents analysed included reports in the Educational Planning and Research library, studies obtained from the Ministry of Human Resources, and relevant sections of the various national development plans. Data on enrolments, intake and output was collected directly from institutions of higher learning through a small scale survey. This included returns from selected local universities and private colleges. Interviews with representatives of some large scale employers and Deans of several faculties in universities provided suggestive insights into levels of satisfaction with science students graduating from the school system. From the data collected estimates of supply and demand for science school leavers in further and higher education and in the labour market were made.

1.2 The school survey data - sampling and administration

The survey was planned to sample Malaysian schools and included detailed instruments for school principals and science teachers. A small scale student questionnaire was developed for use in some case study schools. Experience with previous school surveys indicated that response rates were enhanced and questionnaire administration facilitated when personal contact was made with school principals. Practically speaking this could only be arranged by restricting the spread of schools so that fieldworker's travel would be manageable. Sampling was, therefore, confined to four states which reflected the geographic and economic diversity of the country.

1.2.1 The four states were Wilayah Persekutuan (developed and urbanised state), Perak (large, developing, west coast state), Terengganu (less developed, east coast state) and Sarawak (rural and less developed East Malaysian State). Wilayah Persekutuan has no education districts. Education districts in Perak and Terengganu were first classified into developed, moderately developed and less developed districts. Each district was assigned an identification number and random sampling was used to select the districts. Four districts were selected in this way from Perak and three from Terengganu. In the case of Sarawak, districts were selected based on accessibility from Kuching.

1.2.2 Within the selected districts, schools were classified by location (urban/rural) and enrolment (school size) before random selection of schools was carried out. In this way 96 schools were identified to produce a sample that was broadly representative of all schools in the four states (*see Chapter* 2).

1.2.3 Questionnaires for principals and for science teachers were administered in all schools. For the purposes of this study a science teacher was defined as one who taught a minimum of 8 periods of science per week. In Terengganu, Wilayah Persekutuan and Perak, fieldworkers met with principals of sample schools and this made it possible for individual schools to be provided with the exact number of questionnaires required for science teachers in each school. For schools in Sarawak a meeting was not possible and an estimate of the number of science teachers likely to be in the schools had to be made on the basis of total enrolment. Selected groups of students in the case study schools from Form II and Form IV arts and science were questionnaired but the results were of limited value because of sampling difficulties.

1.2.4 The questionnaires for school principals and teachers were designed after small scale investigations in several schools, discussions with those well informed about the problems of science education, and consideration of issues emerging from preliminary work. This ensured that major areas of concern were addressed. It was also valuable in refining questions related to complex issues, e.g. the adequacy of resources (equipment, consumables, etc.) and patterns of expenditure on science at the school level. Draft questionnaires were pre-tested in two urban schools in Kuala Lumpur. Revised versions were then tried out in a rural school before being finalised. The final questionnaire instruments were discussed with science curriculum officers, State science supervisors and officers of the Science Unit of the Ministry of Education's School Division.

1.2.5 Both questionnaires were designed in several parts. These included sections on biographical information (e.g. training, level of education, experience), arrangements for teaching and learning science (e.g. time-table allocations and teaching loads, teaching methods, availability of resources and support), and attitudes and perceptions towards different aspects of science education (e.g. opinions on science curricula, attitudes to changing patterns of enrolment). The principal's questionnaire contained a range of questions designed to gather basic data on enrolment, achievement, staffing, etc. at the school level, whilst the emphasis of the teacher's questionnaire was on individual science teacher's characteristics, teaching approaches and perceptions. As far as possible instruments were precoded.

1.2.6 Assistance in questionnaire administration was sought from the relevant State and District/Division Education offices in the states where fieldwork was to be conducted. Three teams of two researchers were assigned to each state. Visits were made to the relevant District/State Education Offices to brief principals of schools in the main sample on the administration of the questionnaire. Teacher questionnaires were distributed by principals and teachers were invited to return their completed questionnaires in sealed envelopes directly to various collection points. In Sarawak questionnaires were administered postally as no other arrangement was feasible. A cover letter outlining administration procedures was provided for principals. The questionnaires were administered over the months of March and April 1991. Non responses were followed up twice before attempts to obtain the completed questionnaires were abandoned. Response rates are given in *Chapter 2.*

1.3 Case-studies

The case-study schools were selected from the main survey sample in three of the four States, the exception being Sarawak. It was not possible to include schools in Sarawak for the case studies due to time and financial constraints. Eleven ordinary/general secondary schools were identified, five in Perak, and three each in Terengganu and Wilayah Persekutuan. The selection was designed to achieve a balance between urban and rural schools and high and low scoring schools on science results in Form III. Initial attempts to identify schools that were improving or deteriorating in examination results indicated the analytical complexity of making judgements of this kind. Changes in overall pass rates tended to conceal differences in the distribution of grades (thus for example some schools improved passes with a drop in the number of credits and distinctions, others increased the number of credits and distinctions but suffered reduced overall passes). Two special science schools, one a science residential school and the other a MARA Junior Science College were added to give an additional dimension to the case studies. This led to a final total of 13 case study schools.

1.3.1 Various data collection techniques were employed to ensure that data generated from the case studies both captured the special characteristics of science education in the schools and also covered a common agenda of issues on which insight was needed. The methods used ranged from those which were relatively unstructured and responded to issues raised by respondents, and those which were more structured and reflected matters of general concern identified from other parts of the research programme. Corroboration across the data was sought wherever possible to cross-check important observations. The initial agenda for the case studies was identified from field visits to four schools around Kuala Lumpur, discussions with appropriate professional officers of the Ministry, and documentary analysis of reports and evaluation studies. This was carried out in February 1991. Preliminary case study instruments were developed to collect specific information, e.g. on consumable materials, equipment, allocation and expenditure of funds for science, physical facilities and resources, and teaching and learning materials.

1.3.2 Drafts of case study instruments were piloted in two urban schools, amended and tried out again in a rural school. These instruments were finalised at a residential workshop conducted in March 1991. The main structured instruments used in the case-studies are indicated in *Table A.1* along with an indication of other sources of data.

1.3.3 The case-studies were conducted in two phases (the detailed case study and a follow-up visit). Planning was done to ensure that fieldwork did not coincide with examinations or other events that disrupted the normal working of the schools. Scheduling also had to make allowances for the different weekends observed in the different states. The relevant education district offices and case study schools were invited to participate and given information on the duration and nature of the activities. A coordination meeting preceded each fieldwork exercise where case study researchers agreed on a division of responsibilities and time-tabled their activities. In all cases teams met with the school principal and/or senior assistant first and negotiated the pattern of work. Courtesy visits were also made to the District Education Offices and the State Education Department where this was possible.

Table A.1 Case study instruments and other sources of data

Type	Focus
Interview Schedules	∘ Principal ∘ Senior Assistant ∘ Science Teacher ∘ Laboratory and Technician ∘ Guidance and Counselling Teacher ∘ Library Teacher
Observation	∘ Lessons ∘ School Environment/ Climate
Checklists	∘ Laboratory Equipment ∘ Consusmables ∘ Furniture/Fittings ∘ Science Funds ∘ Physical Facilities
Time Tables Collected	∘ Laboratory ∘ Teachers/Personnel ∘ Class
Documents Examined	∘ Visitors'Book ∘ Student Exercise/Activity ∘ Books ∘ School Blueprint ∘ Minutes of Panitia Meetings ∘ Circulars ∘ School Magazines ∘ Examination (SRP/SPM/STPM) Results ∘ Textbooks

1.3.4 The fieldwork was undertaken between April and July 1991. The first visits lasted 5 to 6 days in each school. In the course of this, baseline data on the school and its staff and students was acquired, relationships with staff were built and assessments made of the facilities and equipment available. The conditions of teaching and learning science were also explored through interviews with teachers and observations of some lessons. Follow-up visits were made in August after preliminary analysis and writing up. During the follow-up visits information gaps which had been identified were filled and further explanation of problems and issues was explored. With 4 teams of researchers working in pairs, fieldwork and the write up of individual case study reports was accomplished in about 14 weeks. Requests for detailed information, e.g. on income expenditure and examination results were made early in the visit to enable school records to be consulted and information to be complied. Checklists were used to standardise some data collection. Day-to-day adjustments were made on the basis of evening coordination meetings. Case studies in the same States were undertaken concurrently allowing inter-team discussions to be carried out.

1.3.5 Semi-structured interview schedules were prepared for each category of informant. This ensured that key issues were not overlooked. The format also allowed interviewees to raise issues of particular concern to them. Thus, researchers were not required to use interview schedules rigidly so that interviews could flow as naturally as possible. Interviews with school principals/senior assistants were aimed at establishing basic information about the school, the pattern of provision of science and the problems associated with this. Interviews included personal biodata, school level data on the catchment area, facilities, staffing, time-tabling, finance, perceptions of the aims and problems of science education, effectiveness of the support system and the destinations of school leavers. Science teacher interviews delved into areas which included biodata, teaching loads, personal aims of teaching science, teaching conditions, patterns of teaching, and assessment, problems of teaching science including the identification of difficult topics, the value of in-service training, and provided insights into teachers' motivation and commitment. Interviews with laboratory technicians encompassed areas such as biodata, workload, resources available as well as perceptions of teaching and learning problems.

1.3.6 All available science-related school documents were studied. These included the school blueprint, which spells out priority areas for improvement at the school level. The Visitor's Book was checked as this provided a record of all visitors to the school. It was thus useful in determining the extent and frequency of support and advisory visits related to science. Records of income and expenditure provided information on the pattern of expenditure on science. Students' workbooks and exercise books were analysed to determine the type and frequency of assignments and practicals and the general quality of work. Class and teachers' personal time-tables were used to fix appointments for teacher interviews and classroom observations as well as to analyse the distribution of science periods. Laboratory time-tables were analysed to ascertain the rate, frequency and distribution of laboratory use.

1.3.7 The writing up of case-study reports took place after researchers returned from the field. There was no standard division of the responsibility for writing up the case studies and each research team developed its own strategy. The first three case study accounts were discussed and became the basis for the general format for all case study reports. The case study accounts were synthesised into a single report in September and October 1991.

1.4 The performance analysis

The analysis of performance was designed to explore patterns of achievement in science amongst students. It had two main components. First, the results of the public examination at SRP level (Form III), and SPM (Form V) were scrutinised for the last three years to determine recent changes in pass rates and the ratio of distinctions, credits, and passes in the different science subjects. Second, procedures were developed to use item analysis to gain insights into the kinds of examination questions students found most difficult. This was used to identify the patterns of performance of different groups of students.

1.4.1 In the item analysis responses to multiple choice items were analysed. Facility values were used to indicate the proportion of students who identified a correct response from a list of alternatives. Those questions with the greatest facility values are the easiest and vice versa. Facility values can vary between one (all candidates get the correct answer) and zero (all candidates fail to identify the correct answer).

Questions can then be arranged in order of difficulty. Item analysis was conducted on a sample of scripts from the 1990 SRP and SPM science examinations. The sample was drawn from 9 categories of schools, namely:

(a) Science Residential Schools
(b) Fully Residential Schools
(c) MARA Junior Science Colleges
(d) High Scoring Urban Schools
(e) High Scoring Rural Schools
(f) Low Scoring Urban Schools
(g) Low Scoring Rural Schools
(h) High Scoring Boys Schools
(e) High Scoring Girls Schools

1.4.2 This enabled questions to be listed in order of difficulty for SRP Integrated Science (75 items) and SPM General Science, Physics, Chemistry and Biology (40 items each). We were not able to analyse other parts of the SPM examination which were not multiple choice.

1.4.3 The results of the re-analysis were used to undertake two main types of enquiry. First we identified questions which were the most difficult, and by implication where teaching and learning problems may be greatest. Second, we highlighted questions which generated the largest differences in performance between students in different types of school. The latter was felt to be helpful in drawing attention to special difficulties experienced by those groups whose performance was unsatisfactory. The sample used in analysing performance was constructed with the help of the Examinations Syndicate. It was selected from all secondary schools with Form I to V in Wilayah Persekutuan, Perak, Terengganu and Sarawak.

1.4.4 In all 5,706 scripts were analysed for SRP Integrated Science, 6,002 for SPM General Science, 5,058 for SPM Physics, 5,047 for SPM Chemistry and 4,966 for SPM Biology. At SRP level this represented 2.4 per cent of the national population. At SPM it represented about 5.5 per cent of the national population for General Science and 11 per cent for the other science examinations. Students were drawn from the same schools for both the SRP and SPM samples and all students in the selected schools taking the appropriate examinations were selected.

The SPM separate science subjects were all taken by the same students. The SPM General Science students were in the arts streams of the schools from which the science stream students were selected.

1.4.5 High and low scoring schools were identified using overall performance in science on the relevant examinations. The most extreme cases of high and low scoring schools were taken. Urban and rural schools were located using the Ministry's classification of schools. Four boys and four girls schools were chosen as the only convenient way of exploring differences between boys and girls since the candidate data is not recorded by sex. It is important to note that most single sex schools are high achieving.

1.4.6 A number of procedures may be used to analyse the performance of students in different groups of schools. Facility values for individual questions can be simply correlated. Thus, an examination question might have a facility value of 0.75 (75 per cent of students answer correctly) for rural students and 0.85 (85 per cent of students answer correctly) for urban students. It would, therefore, be easier for the average urban student. A refinement of this is to consider the relative difficulty of different questions by asking "How does this question compare in difficulty with other questions for rural students? How does this relative level of difficulty compare with the relative difficulty of the same item for urban students?" A question might be the fifth easiest for rural students and the twentieth easiest for urban students. It would, therefore, be relatively easier (compared to other questions) for average rural students despite probably being absolutely more difficult. This approach was adopted in some of the analysis reported in the text.

1.5 Concluding note

Five separate research reports were produced relating to each component of the research. These were:

The Baseline Study on Secondary School Science Education in Malaysia.

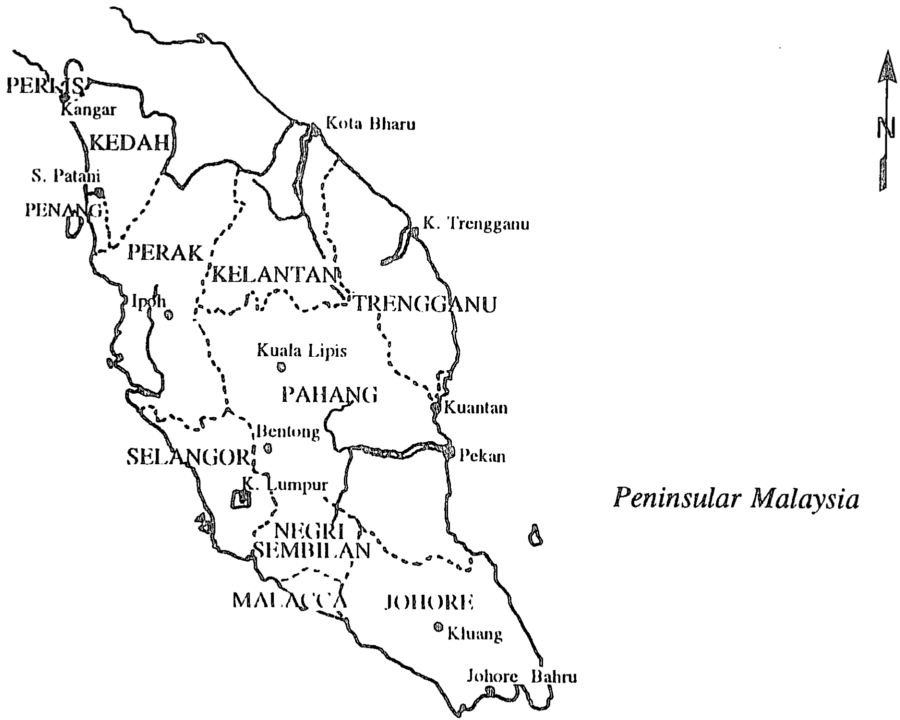
The Flows of Students through the School System.

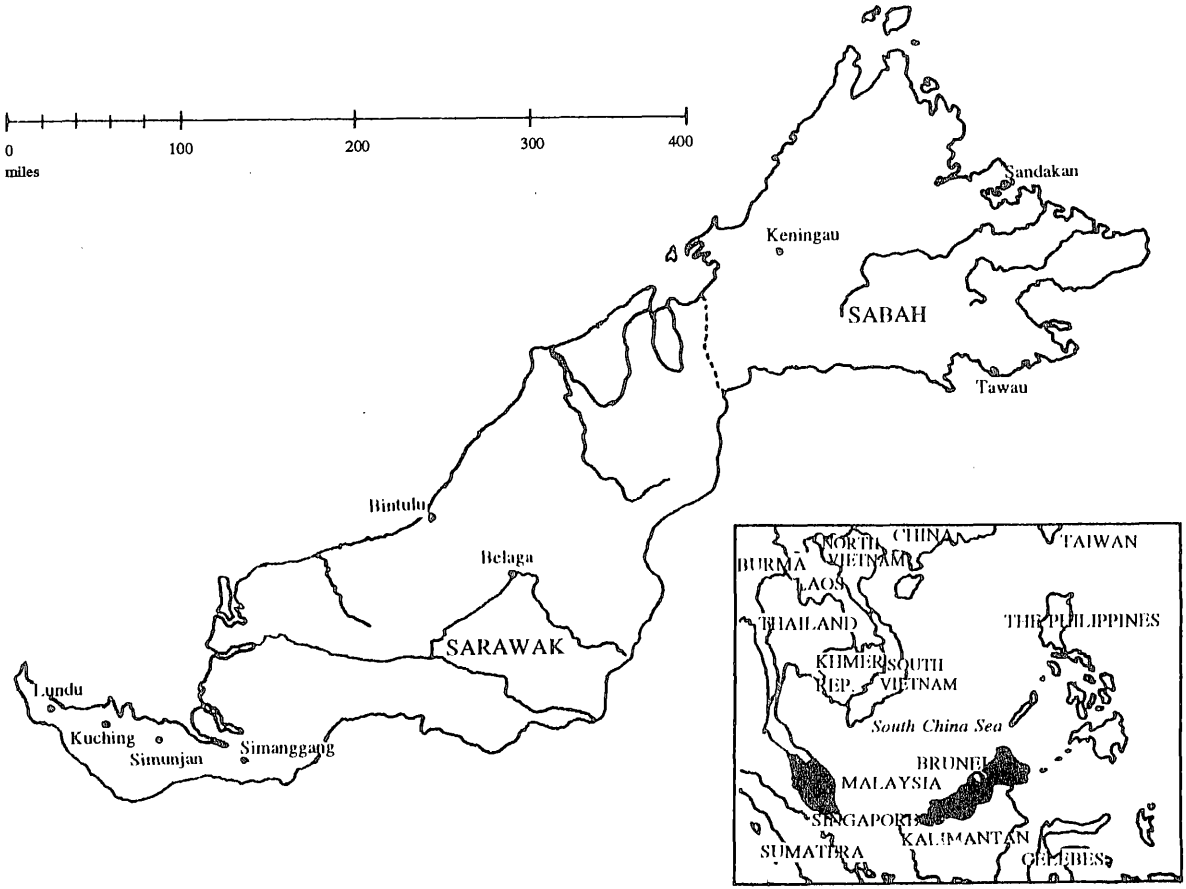
The School Case Study Reports – Synthesis.

The Report on the Survey Data.

The Analysis of Performance on SRP and SPM Science Examinations.

Map 1. Malaysia by state




0
100
200
300
400
miles
Sandakan
Keningau
SABAH
Tawau
Bintulu
Belaga
SARAWAK
Lundu
Kuching
Simunjan
Simanggang
CHINA
TAIWAN
NORTH VIETNAM
BURMA
LAOS
THAILAND
THE PHILIPPINES
KHMER REP.
SOUTH VIETNAM
South China Sea
BRUNEI
MALAYSIA
SINGAPORE
KALIMANTAN
SUMATRA
CELEBES

Bibliography

Arshad Marsidi. 1990. *Training in Malaysia: issues and options*. Human Resource Development Project MAL/87/015 Module IV; Education and Training. Government of Malaysia/ILO/UNDP.

Ministry of Education, Malaysia, Schools Division. *Analisis Keputusan Peperiksaan Sijil Pelajaran Malaysia (SPM) 1986-1989 Sekolah-Sekolah Berasrama Penuh.*

Ministry of Education, Malaysia, Educational Planning and Research Division. 1988. *Dasar Pendidikan Berasaskan Sains dan Teknologi di Peringkat Menengah Atas.*

Ministry of Education, Malaysia, Educational Planning and Research Division. 1990. *Wastage in education: a case study of Malaysia.* (Unpublished).

Ministry of Education, Malaysia, Educational Planning and Research Division. 1981–1990. *Educational statistics of Malaysia.*

Ministry of Education, Malaysia, Educational Planning and Research Division. 1989. *Educational planning: projection of teachers in primary and secondary schools 1990-2000 based on stock of teachers in 1989.*

Ministry of Education, Malaysia, Federal Inspectorate of Schools. 1989. *Laporan Tahunan.*

Ministry of Education, Malaysia. 1975. Curriculum Development Centre. *Sukatan Pelajaran Malaysia Kimia Tingkatan, IV-V.*

Ministry of Education, Malaysia. Curriculum Development Centre. 1975. *Sukatan Pelajaran Malaysia Fizik Tingkatan IV-V.*

Ministry of Education, Malaysia. Curriculum Development Centre. 1975. *Sukatan Pelajaran Malaysia Biology Tingkatan IV-V.*

Ministry of Education, Malaysia. Curriculum Development Centre. 1982. *Sukatan Pelajaran Malaysia Rampaian Sains Tingkatan IV-V.*

Ministry of Education, Malaysia (1978). Curriculum Development Centre. *Sukatan Pelajaran Sains Paduant Tingkatan 1, 2, 3.*

Ministry of Education, Malaysia. Curriculum Development Centre. 1988. *Sukatan Pelajaran Sekolah Menengah Sains.*

Ministry of Education, Malaysia, Curriculum Development Centre. *Huraian Sukatan Pelajaran Sains Tingkatan 1.*

Ministry of Education, Malaysia. 1990. *Huraian Sukatan Pelajaran Sains Tingkatan II.*

Ministry of Education, Malaysia. 1989. *Huraian Sukatan Pelajaran Sains Tingkatan III.*

Ministry of Education, Malaysia, Higher Education Division. Program Pelajaran Tinggi, Rancangan Malaysia Kelima. 1986-1990. Bab, C; *Dasar, Matlamat dan Strategi.* (Unpublished).

Ministry of Education, Malaysia, Higher Education Division. Program Pelajaran Tinggi, Rancangan Malaysia Kelima. 1986-1990. Bab, A: *Ringkasan.* (Unpublished).

Ministry of Education Malaysia, Federal Inspectorate of Schools 1987. Laporan Projek Sains 1987. *Pengajaran dan Pembelajaran Fizik dan Kimia (SPM)*

Ministry of Education, Malaysia, Schools Division. 1987. *Panduan Pengurusan Makmal Sains Sekolah.*

Ministry of Education, Malaysia, Schools Division. 1987. *Surat Pekeliling Ikhtisas 1984-1987.*

Ministry of Education, Malaysia, Schools Division. 1979. *Surat Pekeliling Ikhtisas 1979-1983.*

Ministry of Education, Malaysia. *Laporan Kemajuan Pelksanaan Perakuan-Perakuan Laporan Jawatankuasa Kabinet Mengenai Pelajaran bagi tahun, 1982-1983.*

Ministry of Education, Malaysia, Examinations Syndicate. 1990. *Laporan Prestasi SRP 1986.*

Ministry of Education, Malaysia, Examinations Syndicate. 1990. *Laporan Prestasi SRP 1987.*

Ministry of Education, Malaysia, Examinations Syndicate. 1990. *Laporan Prestasi SRP 1988.*

Ministry of Education, Malaysia, Examinations Syndicate 1986. *Laporan Prestasi SPM/MCE 1985.*

Ministry of Education, Malaysia, Examinations Syndicate. 1990. *Laporan Prestasi SPM 1986.*

Ministry of Education, Malaysia, Examinations Syndicate. 1990. *Laporan Prestasi SPM 1987.*

Ministry of Education, Malaysia, Educational Planning and Research Division. *Pelaksanaan KBSM: Penyertaan Pelajar Tingkatan 4, 1992 Dalam Mata Pelajaran Elektif.* (Unpublished).

Ministry of Human Resources, Malaysia, Manpower Department. 1988. 1989 and 1990. *Vacancies in the private sector at diploma and degree level.*

Ministry of Human Resources, Malaysia, Manpower Department 1990. Report on *Vacancies by sector and areas.*

Ministry of Human Resources, Malaysia. 1991. *Trend Gunatenaga,* Vol. 6.

Ministry of Science and Technology, Malaysia. 1990. *Industrial technology development: a national plan of action.* A Report of the Council for the co-ordination and transfer of industrial technology and the environment.

Ministry of Science and Technology, Malaysia. 1970. *Science and technology policies, trends and infrastructure.*

Prime Minister's Department, Public Services Department. 1990. Interim Report: *Public sector manpower master plan study.*

Prime Minister's Department. 1990. *Sixth Malaysia Plan.*

Prime Minister's Department, Economic Planning *Unit. Mid-Term Review of the Fifth Malaysia Plan 1986-1990.*

Prime Minister's Department, Economic Planning Unit. 1991. *Malaysia Di Abad Ke 21: Pembangunan Sumber Tenaga Manusia.* A paper presented at the seminar 'Pendidikan Sains Abad Ke 21: Reformasi Pendidikan', 10-13 November 1991.

Prime Minister's Department, Economic Planning Unit. *Economic report 1990/1991.*

Prime Minister's Department, Malaysia. 199*1. The second outline perspective plan, 1991-2000.*

Prime Minister's Department, Malaysia. 1991. *Malaysia: the way forward.* Vision 2020.

Sulaiman, M.; Yassin et al. 1990. Malaysian Human Resources Development Plan Project. Report on *Education.* UNDP. Economic Planning Unit, Prime Minister's Department, Malaysia.

Universiti Teknologi Malaysia. 1990. *Tracer study on graduates of polytechnics, technical and vocational schools.*

IIEP publications and documents

More than 650 titles on all aspects of educational planning have been, published by the International Institute for Educational Planning. A comprehensive catalogue, giving details of their availability, includes research reports, case studies, seminar documents, training materials, occasional papers and reference books in the following subject categories:

Economics of education, costs and financing.

Manpower and employment.

Demographic studies.

The location of schools (school map) and sub-national planning.

Administration and management.

Curriculum development and evaluation.

Educational technology.

Primary, secondary and higher education.

Vocational and technical education.

Non-formal, out-of-school, adult and rural education.

Copies of the catalogue may be obtained from the IIEP Publications Unit on request.

The International Institute for Educational Planning

The International Institute for Educational Planning (IIEP) is an international centre for advanced training and research in the field of educational planning. It was established by UNESCO in 1963 and is financed by UNESCO and by voluntary contributions from Member States. In recent years the following Member States have provided voluntary contributions to the Institute: Belgium, Canada, Denmark, Finland, Iceland, India, Ireland, Norway, Sweden, Switzerland and Venezuela.

The Institute's aim is to contribute to the development of education throughout the world, by expanding both knowledge and the supply of competent professionals in the field of educational planning. In this endeavour the Institute co-operates with interested training and research organizations in Member States. The Governing Board of the IIEP, which approves the Institute's programme and budget, consists of eight elected members and four members designated by the United Nations Organization and certain of its specialized agencies and institutes.

Inquiries about the Institute should be addressed to:
The Office of the Director, International Institute for Educational Planning,
7-9 rue Eugène-Delacroix, 75116 Paris, France.

The book

Malaysia, one of the newly industrializing countries of Asia, has given a high priority to educational development, in general, and to science and technology, in particular. As from the 1960s, a sustained effort has been made to expand and improve the quality of science education at all levels. Sufficient time has passed for the effects of the policy interventions in the area to be assessed. Such is the object of the present study.

It describes and analyzes the main characteristics of the provision of science education at secondary level and investigates science education provision empirically through a national survey and a series of case studies located in selected schools. It draws conclusions related to improvements in the planning and support system for science education, and suggests new mechanisms for policy implementation.

The authors

Sharifah Maimunah bte Syed Zin is Principal Assistant Director of the Evaluation Unit of the Educational Planning and Research Division, Ministry of Education, Malaysia. Previously, she worked in a State-level education department and in the National Curriculum Development Centre in Kuala Lumpur. She holds a Master's Degree from Sussex University and a PhD from East Anglia University.

Keith M. Lewin has worked on educational projects in a wide range of developing countries over the last 20 years. His special interests include science education and development, science policy in newly industrializing countries, and financing education systems. He is a staff member of the University of Sussex, United Kingdom, and is a university associate of the Institute of Development Studies. He is the author of various publications including *Education in austerity: option for planners* and *Science education in developing countries: issues and perspectives for planners*.