3 Technology for Management and Efficiency in Education

Understanding the Issues

Centralised and Decentralised Education Systems

Successful management of education systems has always depended on having the necessary information available, as much as on having personnel trained and experienced in management. It is equally important to have this information in a timely manner, and in a form appropriate for the intended purpose. Information enables education officials to keep their fingers on the pulse of the system, and make sensible decisions affecting the status and routine administration of education in the country. This entails having a wide range of information about learners, teachers, facilities and resources that make up an education system. For each of these categories different kinds of information are required, depending on the purpose, and on the level of decision-making at which the information is to be used. In this regard it is important to distinguish between centralised and decentralised education systems, since this factor helps to determine the level at which various kinds of information are used for making decisions or for taking action related to the system.

In highly centralised systems it is often the case that teachers, who collect the data at source, do not have a stake in the use of much of the information they are expected to collect. Generally data is collected as a matter of routine and out of a sense of duty, rather than for intrinsic professional reasons. In decentralised systems, however, where many decisions are taken locally, teachers and school heads tend to be more aware of the strong links between information collected and the management or decision-making process they are expected to perform. There is therefore a strong case for decentralisation in education, since it is likely that data will be collected more meticulously and used more appropriately in a decentralised education system than in a highly centralised one.

In large Commonwealth countries such as Australia, Britain, Canada, India, Nigeria and Pakistan the education system has traditionally been decentralised. This is usually due to the existence of a fairly decentralised form of government in which there are strong local authorities in charge of education. In the small states of the Commonwealth, their size suggests that they will continue to have a more centralised system of government. But even in small states, devolution of authority and decision-making powers to schools is a growing trend in education.

In most other Commonwealth countries, however, the system of government has been recently in a state of transition, from highly centralised to fairly decentralised. International and pan-Commonwealth efforts to strengthen democracy through greater transparency and accountability have given rise to a new trend that emphasises greater decentralisation of government. In addition to this wider socio-political pressure, there

have been pressures from within education systems for greater decentralisation. This stems from growing criticism of education systems that offer a centrally designed curriculum that is not relevant to some communities. Increased budgetary difficulties have also meant that local communities are being required to play an increasing role in the financing of education. With these and similar critical trends in education, many countries have made intensive efforts to decentralise their education systems. The main concern has been to make education more relevant to local needs and more accountable to the local communities that schools are supposed to serve.

Reasonable success has been achieved in this area, but the Education Management Information System (EMIS) in many of these countries still suffers from a range of difficulties, including the negative effects of a 'centralised culture'. This means, for instance, that in some countries the Ministry of Education still does not have adequate or reliable disaggregated statistics on the education system. The problem is often due to poor record-keeping and inefficient data collection as the system goes through the transition from a centralised to a more decentralised structure. At each level, from the schools to the district offices, to the provincial offices, up to the central ministry, there are weaknesses in the generation, storage, retrieval and use of information for management purposes. However, even in countries that have a fairly efficient EMIS in place, there can be difficulties and weaknesses in this area.

Problems with EMIS

Weaknesses in EMIS generally stem first from a lack of motivation for proper collection and handling of management information. Data collection and record-keeping tasks can easily be seen as imposing an extra administrative burden on teachers and school heads, unless they themselves appreciate and make use of such information for intrinsic professional reasons. In Britain, for instance, recent Labour government policy on the quality of education and moves towards verifiable national standards, have prompted reactions protesting against an envisaged rise in the workload of teachers due to an increase in required testing and record-keeping. Clearly, even in a decentralised education system with a good EMIS tradition, national policies and strategies can have a controversial impact on the amount of work involved in the collection and management of information at local as well as national levels.

The question of motivation therefore becomes important for those who are expected to take on such an additional workload. What is most critical in this respect is the kind of professional motivation that can be achieved when teachers and school heads readily identify with the new policies and strategies, and are keen to implement them fully. Motivation alone is not always adequate, for any new or additional workload has implications for the efficiency with which normal duties like teaching and administration are carried out in schools. Besides there are also controversial issues concerning fair remuneration and adequate benefits for additional work.

The second source of problems and weaknesses in EMIS stems from accountability or the lack of it. This is particularly true of highly centralised education systems that require information to be collected routinely and passed upwards through a hierarchy of bureaucratic levels. This kind of centralised culture often means that there is a relative lack of accountability at the local level, so that sloppy collection, inefficient handling or outright false manipulation of information has no clear or immediate repercussions. In

the worst cases enrolment figures can be inflated and staff numbers increased artificially, where an institution stands to benefit from this in terms of resource allocation or supplement for teachers' salaries. Many developing Commonwealth countries have suffered a drain on their scarce education resources, due to the phenomenon of 'ghost teachers' and 'phantom pupils'. Similarly there have been problems with malpractice in the conduct of national examinations at the local level and in the compilation of performance data for use at the national level.

A third major reason for weaknesses in EMIS is lack of training. It is necessary to provide proper training for teachers and school heads if they are expected to perform data collection tasks in an efficient and reliable manner. This is not simply a matter of training them to make entries in the various record documents. It involves developing the skills to carry out initial processing of data so that it can be presented in a form that is useful at the school level and beyond. Teachers and school heads need to understand and appreciate some of the uses to which such information can be put for various purposes and at various stages in the system. Moreover, training should provide them with an appreciation of the importance of errors and the techniques for minimising them in data collection and processing. Providing appropriate training in these areas is likely to remain a major problem for many developing Commonwealth countries whose education systems have a high proportion of teachers without even the basic pedagogical and professional training. However, there have been some successful attempts, which demonstrate that training for data collection and processing can be provided readily through a series of in-service programmes.

A fourth and critical factor that accounts for weaknesses in EMIS is the means of doing things – the predominant EMIS technology. The means of collecting and processing information determines the quality of the EMIS from the collection of raw data, through various stages of collation and analysis, to the point at which it is used for action and decision-making. In situations where information is generated and stored using the most basic means, such as written entries in attendance registers, mark books, record cards and report forms, the process is very laborious for both teachers and school heads. There is increased chance of error at the information-collection stage, and in subsequent processing of the information at the local level. With such basic means of recording and storing data and information, it is very difficult to use it fully and efficiently. For instance, it is necessary to trawl through the various record documents in order to compile any kind of aggregate information required for action and decision-making. It is also difficult to transfer such data to other points in the system where it may be needed for making decisions or taking action.

Where low-technology EMIS is prevalent, transfer of data and information is a serious problem. Frequently information has to be transported physically from schools to district offices where it is collated and processed. The results then have to be taken physically to provincial offices, where the same process takes place, and again the processed information needs to be taken physically to the central ministry. This manual transfer of data and information invariably involves the use of school heads and inspectors (with associated transport costs) in order to guarantee 'safe delivery'. Moreover, in some countries this has come to be seen as one of the most important functions of school heads and inspectors, with the data usually being treated as prized confidential material. In practice this means that expensive supervisory and managerial staff are being used essentially as postal agents in the education system.

Another major problem resulting from the manual collection, processing and transfer of information is that of time lag. The typical time-lag chain starts with delays at the school level in collecting and processing the required data. This means that districts do not have the information they need in time to make important decisions. They cannot provide the provincial offices with the necessary information on time, and in turn the central ministry cannot get the information it requires in a timely manner. All of this means that decisions on the allocation of resources, posting of teachers, supply of materials and so on, often have to be made on old information or on guesswork. It also means that users of the system – including students, parents, local communities, government departments and employers – cannot readily access important educational information in a timely and reliable manner.

The issue of transfer of data and information is important also because it influences attitudes towards its collection, processing and storage. In principle there is a tension between local and central use of such information. The question that then arises is whether data is collected and processed mainly for use at the school level or simply for transmission to levels beyond the school. It needs to be appreciated that there is usually a trade-off between the collection and processing of management information on the one hand, and getting on with the professional tasks of teaching and learning on the other hand. Understandably, excessive demand to collect and process data can be regarded by teachers and school heads as an unwelcome burden if much of this is simply for transfer to levels beyond the school. However, if such information is seen as beneficial to the work of the school and its accountability to the community it serves, there is likely to be a much greater degree of willingness and even enthusiasm to carry out the tasks involved in data collection and processing.

Quite apart from educational data, it is often necessary to make use of additional data from outside the education system to promote proper planning and management. This usually includes data on population characteristics, household incomes, community profiles and labour market trends. Typically, most of this kind of data is not captured in the conventional EMIS that tends to be more focused on standard educational data. There is therefore a wide range of educational and external information required for proper planning and management of education systems.

The Rationale for Collecting and Processing Data

Against this background of information needs and weaknesses in the collection and processing of data, it is important to appreciate that these activities are not simply ends in themselves, but are the means to something else. The rationale for collecting and processing data is to facilitate informed decision-making and sensible action in the best interest of education. Efforts to improve data collection and processing are not to be pursued at the expense of these wider objectives. In this regard there are at least three levels of problems faced by many developing Commonwealth countries.

First is the issue of what is worth collecting and the quality of what is being collected. In some cases, even where there are commendable efforts to keep proper records, the quality of the data collected is so suspect that its usefulness is doubtful. Many developing countries have made commendable progress in this area, in so far as they can at least provide reliable aggregate figures for such basics as enrolment, staff numbers and even educational expenditures. However, most of these countries still have much work

to do when it comes to improving the quality and reliability of more disaggregated data or other critical categories of data. This is often because data is typically aggregated at various levels (district, province, etc.) before it reaches the central ministry. Many countries have made progress with the collection of school-level data that can facilitate disaggregated indicators at the central ministry level. Success in this area depends not only on improved processing capacity, but on reliable record-keeping at the school level. Efficient transmission of data to the central ministry and other levels where it is needed for various purposes is also important. In each of these areas it is necessary to explore fully the possible ways in which technology can best be used to enhance performance.

Second is the question of what is done with the data collected. For most countries where collection of raw data is a problem, useful analysis of that data presents an even bigger problem. This has a lot to do with the transition from simply collecting and tabulating data to interpreting and analysing it. There are standard statistical techniques for processing data of course, but decisions as to what indicators should be extracted from it, and why, are at the heart of good analysis. These decisions in turn should help to determine what kind of data is worth collecting in the first instance. While many countries now routinely produce reliable standard statistics on enrolment, it is rare to have the same kind of indicators when it comes to such critical factors as lateness, absenteeism, drop-out and even repetition. Yet these are now regarded as being at the heart of understanding the complexities of access, retention and even achievement in education. They are also the main kinds of indicators that are most useful for local action and decision-making. The implication is that more and different kinds of data may have to be collected and analysed. Here again the use of technology needs to be fully explored as a means of facilitating improvements in the quality of data collection and analysis.

The third level of difficulty has to do with the quality of decision-making and action that results from the use of data processing and analysis as part of an EMIS. In far too many countries, the links between such analysis and policy decisions tend to be poor and tenuous at best. Yet the main reason for collecting and analysing data is to inform policy decisions and strategic action relating to the education system. The issue is more to do with interpretation and judgement than the use of technology *per se*. Increasingly, however, the use of sophisticated modelling techniques has been shown to be of great benefit in promoting improvements in decision-making based on data collected and analysed as part of an EMIS. On the one hand, good analysis means that information from the EMIS can provide a basis for proposing various alternative lines of action and policy decisions. On the other hand, good modelling based on the same information enables officials to project into the future and to discern the possible consequences of alternative policies, strategies and lines of action proposed for the education system.

This brief review of key issues has highlighted the fact that information is vital for management and efficiency in education. It has indicated that there are many complex issues to be considered in dealing with information that is likely to be useful to those who manage and take key decisions relating to education systems. These issues relate to the manner in which data is generated, stored, transmitted, retrieved, processed and used for planning and management at different levels of the education system. Clearly technology can play a pivotal role in enhancing an effective and efficient educational management information system. However, it is equally clear that technology is not a panacea for all the complex problems in this area. It is a tool that can contribute to solving these problems, rather than a solution in itself.

We need to assess carefully and systematically where, when and how to use different kinds of technology to develop an efficient and effective EMIS. This entails not just an understanding of what different technologies can do for us, but also some insight into why information is essential, what information is required for different purposes, and how such information is used in planning and management. It is only against such a background of understanding and insight that we can begin to put the role of technology in context and move towards making sensible choices related to the use of technology for management and efficiency in education.

Why Information is of the Essence

Information is the oxygen of good management. It determines the knowledge-base from which critical decisions are made and provides current as well as projected scenarios of the system for which decisions are being made. It indicates how far the goals and objectives set are being achieved; how efficiently the resources provided are being utilised, and how far the governing rules and regulations are being followed.

Information is essential to the life and well-being of education systems for at least three major reasons. First, it is important for proper management and decision-making in the routine administration of the system. In other words, an education system exists only in so far as there are recognisable patterns of operation and procedures guided by key principles, rules and regulations. These need to be maintained constantly at some minimum level to keep the system alive and functioning. In this regard information helps to make education systems more accountable by providing measures of inputs and outputs as well as trends in performance. These are the essentials that define and maintain any kind of system.

Second, information is essential for policy-making and planning for the future development of education. Policy sets out purpose, goals and objectives for education; planning helps to map out the strategies through which these will be achieved. It is policy and planning which give meaning and life to an education system and enable us to talk about effectiveness and efficiency in education. An effective system is one that delivers what it was designed to achieve; an efficient system is one that makes optimum use of available resources to achieve its goals.

Third, information is essential because it facilitates vital research into various aspects of education by providing raw data on different variables. It is through research that we gain greater insight into the achievements and failures of an education system. Research enables us to understand what is working and what is not, as well as why certain things are the way they are, and how other things can be changed for the better. In due course, research helps us to improve the process of education as well as the education system and its impact on society.

It is essential to understand that in practice, these three key strands which define the essence of information are highly inter-related. Good research contributes to policy and planning for the education system, while sound policies and plans set goals and operating strategies for the system. In a reciprocal way, good management and routine administration ensure effective and efficient implementation of policies and plans, which themselves help to put research findings to the test. The common thread running through this complex inter-relationship is information. That is why technology for improvements in the generation, storage, transmission, processing and retrieval of information

is vital for management and development in any education system. *If there is anything worse than a failing education system, it is one in which the managers at various levels are not aware that the system is failing.*

What Kind of Information is Critical?

The kind of information required at different points of the education system depends very much on how centralised or decentralised the system is in practice. It is the degree of decentralisation that determines critical management functions from school level to central ministry level. The management functions in turn determine which kind of information is critical. Most of the information used in the management of education systems originates from individual schools. It is therefore at the school level that we need to encourage a proper understanding of the importance of different kinds of information for the education system. It is critical that teachers and school heads appreciate the usefulness of the information they collect, both for their own purposes as a school and for all other purposes that go beyond the school to district, regional and national levels. The greater a school's autonomy, the more it needs to give careful consideration to its own information needs for decision-making and management purposes. Consideration must also be given to the kind of information that schools are expected to provide for use at other levels – district, region and central Ministry. It is evident that schools need to collect a wide range of information, and may need to review regularly the information collected to determine what is useful to whom, as well as what information they should continue to collect, and for what purpose. In other words, there needs to be a balance between the extent to which information collection is treated as a routine process involving a fixed range of data, and the extent to which it is treated as a dynamic process with regular review of the range of data to be collected.

This balance depends very much on the changing circumstances and realities of the school system. As an education system becomes more decentralised and schools gain a greater degree of autonomy, it is necessary not only to review the range of data routinely collected, and the kind of information needed by the schools, but to review the kind of 'accountability' information through which schools are judged by the community they serve and the central Ministry to which they are also accountable. It may therefore be useful for schools to view the information they collect in terms of data categories that can expand or contract according to prevailing circumstances and information needs. The data categories can then be regarded as relatively fixed, while the actual information collected can be subject to change as the information needs for decision-making change. Table 3.1 (page 84) illustrates the kind of information typically collected in schools, and outlines this in terms of a number of fixed data categories.

In general, the more routine the information requirements, the easier it is for the data collection process to be made simple and routine at the school level. This also means that schools can better handle the data collection and information processing tasks essential for decision-making and management. By the same token, the data that gets to the district and central Ministry levels from the schools becomes more reliable and accurate. The use of technology can play a significant role in promoting these kinds of outcomes, particularly where information requirements can be put in terms of routine data collection and processing to provide standard indicators. Technology can also play a critical role in making changes to the kind of information collected, in order to meet the

Table 3.1 Examples of Information Collected in Schools for Various Data Categories

Data category	*Kind of information typically collected at the school level*
Access data	Number of learners according to age, gender, locality, and other identifying characteristics (religion, race, tribe, etc.). Some schools also record information on number of applicants as well as on the numbers actually accepted and enrolled in the school.
Attendance data	Daily attendance record indicating lateness, absences, etc., usually in the class attendance register. Some schools record reasons for lateness and absences, which may be useful later for analysis.
Data on pedagogical resources	Number of teachers by age, gender, qualification, training, area of specialisation, experience, seniority, etc. Textbooks, equipment and other teaching and learning aids; the availability and use of in-service training opportunities for teachers may also be recorded.
Data on curriculum delivery	Class size; teaching loads; textbooks; learning aids; number of subjects; pattern of availability; timetable; participation in various subjects; specialist facilities; equipment; consumable materials; pupil contact hours; teaching style (record of work lesson notes).
Data on budgetary inputs (income and expenditure)	Staff salary grants; capitation grants; PTA funds; school fees; other charges; community contributions; proprietor funds, etc.; expenditure on salaries and allowances, pedagogical materials, the maintenance of facilities and equipment, routine supplies, services and overheads, etc.
Data on attainment and performance record	Assessment of learning in terms of continuous work and periodic tests as well as internal promotion examinations and major external examinations. In some cases standardised tests at certain grades may be taken for a large sample of schools. Mark Book data and project work record. Record of promotion, repetition, drop-out. Some schools may also record data on behaviour, sports, drama and other areas of performance outside the academic curriculum.

challenges of changing information requirements at different levels of the education system. However, its use here requires much more careful planning.

How Information Can be Used

Information can be used to promote greater effectiveness and efficiency, as well as to present a picture of the system to decision-makers. In other words, it can be used for measuring inputs, tracking processes and measuring outputs in education. It can also be used to make projections about future requirements, and therefore to aid planning for the development of the system – for example, to project future needs for trained teachers, additional classrooms and pedagogical equipment. Table 3.2 shows some possible uses of information in the education system.

Table 3.2 Examples of Possible Information Use at Different Levels

Category of information	*Using information at the school level*	*Using the information beyond school level*
Access data	Level of demand indicated by percentage of applicants enrolled. For high demand a school can decide to make more use of its capacity, or even to expand it, to take in more applicants; to keep enrolment steady in the interest of quality, or to maintain a scarcity that justifies high fees, etc. Dis-aggregated data can also tell if the school is serving its whole community in an equitable manner. Are there far more boys than girls? Is it mainly the rich who get in?, etc.	The distribution pattern of enrolment levels can help to determine policy measures and strategies. Building more schools, expanding existing ones, closing down some small schools, introducing shift systems, using alternative means for delivering education to some groups, etc., are all options that can be taken up as policy depending on what the access data shows for a district, region, or the national system in general.
Attendance data	Can be used to identify learners at risk of dropping out. Poor attendance leads to early drop-out. Also helps identify home/community factors that affect regular school attendance.	Measure of efficiency, since absence and lateness are forms of wastage and reduced learning contact time for the pupils. Indicator of disconsonance between schools and their communities?
Data on pedagogical resources	Can be used to judge how well prepared the school is to meet pupils' learning needs. Also gives a basis for deciding what the school needs to help improve quality.	Can be a basis for deciding on what additional resources and budgets for pedagogy should be allocated to each school. Measure of how 'rich' the schools are in terms of their learning environment. Helps inform decisions on range of new resources required in different categories of schools.
Data on curriculum delivery	Basis for management planning on how best to use available resources for improved delivery of the prescribed school curriculum. Deployment of staff, room allocation, equipment use, etc. can all be planned from this data.	Policy on staff deployment, provision of specialist facilities and setting of targets for school achievement can be based on this kind of data.
Data on budgetary inputs	Income and expenditure indicative of the solvency of the school or how far it is being subsidised, and by whom. Measure of efficiency with which available funds are being used.	Policy on funding of schools and how any subsidies should be targeted. Rules of accountability for the funds provided to schools and the fees they may levy on users or communities.
Performance record data	Indicator of how well the school is doing in serving its clients.	Performance league table. Basis for additional assistance to some schools and for demanding improvements in others.

Overview of Current Practices

Using Technology to Improve Management

In their country papers on education and technology, prepared for the 13CCEM, most countries indicated that technology was being used mainly in connection with education management. The main focus in this regard is on computerisation and the setting up of an efficient EMIS. Many countries have made good progress in terms of computerisation, which has enabled them to produce more reliable and current educational statistics. Despite this progress there is still a very ambivalent attitude towards the use of technology for management of education institutions and systems. In some countries it seems that the introduction of computers in itself is regarded as a progressive step in managing education systems. There is often a striking lack of a coherent strategy and comprehensive plan for using technology to improve educational management. This seems partly due to *ad hoc* decisions made about investing in different technologies at various times, under the influence of commercial companies or as part of projects sponsored by external agencies. Such projects may involve provision of computers and training of staff in specific areas such as educational statistics or sector analysis, but they are not fully integrated into the general educational management process. Similarly, at the school level some institutions succeed in obtaining one or two computers for record keeping and data processing, as part of school management. In other countries, there are impressive developments with systematic attempts to plan and create an EMIS.

Addressing the Challenges

In general, challenges relating to the use of technology for education management can be encountered at the information collection stage as well as in processing, storage, and use of information. The key objectives in using technology efficiently in this area can be summarised as follows:

- move towards a once-only recording or input of data wherever possible;
- increase reliable storage and easy retrieval of data by authorised persons, while restricting the risk of unauthorised access to sensitive information;
- promote easy transfer of data to every point in the system at which it may be needed for management decisions, while minimising the risk of data corruption in transit; and
- promote rapid, accurate and reliable processing of information through the use of standard techniques, procedures and programmes.

In order to meet these objectives, the various challenges at each stage of the information chain must be addressed.

Collection Challenges

The main challenge relating to the collection of information for EMIS is to overcome the inefficiency of repetition (the same information has to be provided at different times

and in different places), while avoiding the restriction of time and place for valid data collection. The two main implications of this challenge are that:

1 Any data or information required should preferably be collected and entered into the system once only. Thereafter it should be accessible whenever and wherever it is required in the system, without having to be collected again or re-entered. This is where modern IT offers definite advantages over the old manual data collection and record-keeping systems.
2 Data and information required should preferably be collected and entered into the system from a variety of places and at various times, in order to avoid bottlenecks and other restrictions of time and place.

In addition, it is of course essential to ensure that the information has been collected with due care and diligence by staff who understand the value of accuracy and reliability in collecting information.

Processing and Storage Challenges

Since information is processed differently for different purposes, the main challenge in this area is the need for flexibility and versatility in handling data processing. The use of standard techniques and procedures in data processing is important for rapid and reliable results. It is also important that data processing is programmed to take account of the information needs at various points in the system. All of this can best be achieved when clearly defined indicators are used, together with standard methods of calculating such indicators from well-specified raw data. The use of computers makes it possible to produce a wide range of indicators through rapid processing of raw data collected and entered into the system. This eliminates the risk of human error in the processing of information, and reduces the problem of long delays due to manual calculations and processing.

However, even with computers problems can arise – for example, when all the raw data is not available in the standard form necessary for calculating a particular indicator. In such situations human judgement comes into play – in deciding how to process the raw data at hand in order to obtain useful results. It is also important to appreciate that despite the high speed and accuracy of computer processing, the results are only as reliable and useful as the original raw data used to make the calculations.

In terms of information storage, the main challenge is to ensure that those who need the information can have ready access to it, while safeguarding it from those not authorised to access it. Electronic data bases are the ultimate means of storage and data files are generally made 'read only' so that the information they contain can be accessed and used but not changed by those who are not responsible for processing the data. With any data storage system it is important to have back-up copies of the data files in case of accidents, and this is easier to do for electronic files than for hard records.

Utilisation Challenges

At one level the use of information in education management is fairly routine and straightforward. It can give us a picture of current reality regarding the size of the

education system (how many learners and staff at each level); the cost of the system in terms of salaries, supplies, maintenance, etc.; and the quality of the system as regards examination results and promotion rates.

At another level, insight, judgement and vision are part of the key to proper utilisation of information in education. This level entails going beyond the indicators and trying to read further meaning into the data as a basis for action or decision-making. This applies at the national as well as local levels, where proper utilisation of information involves a blend of quantitative and qualitative information to guide action, planning and decision-making.

At yet another level, information is used in education management for making projections and predictions on the future impact of some new policy or plan for the education system. In this regard good modelling via the computer can play a key role in rapidly plotting different future scenarios based on current data and some assumptions about the future.

Formulating Policies and Strategies

EMIS Policy

It is commendable that many Commonwealth countries now have a strong desire to establish (or enhance) an educational management information system. For many developing countries this move towards an efficient EMIS has served as the main rationale for introducing computers into the education system. In this regard it is fair to say that some countries have faced a dilemma over the introduction and use of computers for EMIS. Among the issues they have had to consider are how many computers are necessary; where they should be located; whether (and how) they should be linked; what software packages to invest in, and who should be trained to use and access them. For some countries matters have been complicated by the *ad hoc* approach they have been obliged to take in this important policy area, because of pressures from various projects and commercial agents.

In principle there are two broad strategies for introducing computerisation as part of an efficient EMIS. The first is to start with computerisation at the central or Ministry level, and move the process outwards to the regional or provincial level, then to the district or zone level, and finally to the level of the school. This strategy tends to be preferred in the more centralised education systems where the focus is on producing national-level information for management of the system. It is also an attractive option for some countries in the sense that it requires relatively fewer computers and training for a small number of staff. Computerisation can therefore be introduced in a phased and affordable manner. However, this strategy is feasible only if the flow of quality information from the other levels to the central Ministry is timely, reliable and efficient. This can be promoted through the use of other communications technology such as fax machines. If the infrastructure exists, schools can fax information directly to the central Ministry. At least it may be feasible for schools to forward information to the district or regional office, from where it may be possible to fax through to the central Ministry.

The second strategy is to encourage computerisation at the school level, so that the required information can be collected and processed in a more efficient manner, and

made available speedily to those who need it. This strategy means that information can be provided in electronic form by the school, thereby eliminating the need to re-enter it at various points, and reducing the risk of human error which this implies.

Beyond these two broad strategies, computerisation can be extended or deepened in other ways to benefit the education system. For instance, school links can be promoted within a country as well as internationally, to encourage exchange of ideas between teachers, students and administrators, as well as to compare management information and other vital indicators of the education system. It is also possible to promote local area networks (LANs) that link local schools to each other and to the district office. The ultimate would be a national network linking all schools to each other and to all relevant education centres through a national grid, like the one proposed for Britain.

Improved Technology

Deciding on improvements to the technology used for education management information systems involves difficult choices. Given the reality of what obtains in the average school in most developing Commonwealth countries, it may not be feasible to do away with the basic manual record-keeping systems currently in place. However, even in the most deprived schools, the use of simple battery or solar-powered programmable calculators can make a world of difference. This simple technology can increase the speed at which indicators are calculated from raw data, and improve the reliability of information provided by the school by reducing human error in the processing of data. Moreover, such calculators are now so cheap that they are easily affordable even for poor schools.

Schools and countries that cannot afford wholesale computerisation can take a gradual approach to improving transmission technology. Where a fax machine already exists at school or district level, and it is not yet possible to provide a computer, the school data can be faxed to a centre where it can be entered into a computer. The general principle is that making use of whatever level of technology is currently available, and improving on it in a gradual way, depending on what is affordable. It is not necessary to wait until all the latest and most appropriate technologies are available at all levels before embarking on the task of developing an efficient EMIS for the country.

Staff Training

It is important to be realistic about staff training and to have a clear idea of which staff need to be trained in which aspect of information technology. In principle, once the standard data to be collected has been determined and the forms designed, it is possible for fairly junior staff to be rapidly trained to enter the data into a computer. However, manual collation of such data (where there is no computer) needs to be handled by a higher level of staff. In both cases careful supervision of the process by senior staff is required, in order to be able to vouch for the accuracy and integrity of the information provided. Usually, fairly senior educational planners have responsibility for the design of data collection instruments or forms, and these are sent to the schools and other data collection points. The planners need to provide adequate training for staff at the school level who are responsible for collecting and sending the information to them. In terms of data collection then, the important area of staff training concerns the education planners who design the instruments and forms. Beyond this actual collection of the

information is a routine responsibility that teachers and other staff carry out with only basic training.

Where computers are not available at the school or district levels, staff training is needed for processing the information to produce the standard indicators and other statistics required. Where computers are available, staff must be trained to use software for processing the information. In more sophisticated systems it may be necessary to train computer programmers who can develop or customise specific programmes for processing educational information.

The most important area of staff training needs is in the utilisation of information for decision-making and management at all levels. School heads should be in a position to supervise the collection of information and vouch for its accuracy and integrity. More importantly, they should be able to use such information for the decision-making and management processes necessary to operating a good school. This area of training is of great significance, particularly in decentralised education systems. In much the same way, education planners at district level need to be properly trained in how to use data for decision-making and management of the sub-system for which they have responsibility. Beyond this, senior planners at the central Ministry level need to be well trained in using data to guide policy-making and modelling for the system, as well as to provide the standard descriptive and analytical accounts for education in the country as a whole.

Case Study 3: The Use of Information Technology for the Management of Education in Singapore

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The Singapore Education System

In order to understand the use of information technology (IT) in the management of education, it is necessary to have and overview of the key features of the Singapore education system.

The Ministry of Education (MOE) plays a central role in directing and formulating the implementation of education policies. It controls the development and administration of primary and secondary schools and junior colleges. The administrative load is significant, given that there are 193 primary schools, 147 secondary schools and 14 junior colleges. The average number of students per school is about 1,500.

Students take national examinations at several points in their school career. MOE is responsible for processing examination results and for determining the posting of students to schools. The first nation-wide examination taken by students is the Primary School Leaving Examination (PSLE), after six years of primary school education. Based on the results of these examinations, MOE streams students into the Special, Express or Normal secondary-school streams, and posts students to schools. Students in the Special and Express courses sit for the GCE 'O' level exam at the end of their four-year course. The Normal course offers a four-year programme leading to the GCE 'N' level exam. A fifth year is available to students who do well in this exam, to enable them to prepare for and take the GCE 'O' level exam.

MOE co-ordinates the GCE examinations and grading processes, and posts students to junior colleges, centralised institutes, polytechnics, or institutes of technical education, based on their results and preferences. Junior college and centralised institute students go on to sit for their GCE 'A' level examinations after two and three years respectively.

MOE also employs about 23,000 teachers and it hopes to recruit an additional 3,000 in 1998–99. MOE is responsible for interviewing and recruiting new teachers; arranging for their training at the National Institute of Education; posting them to schools; arranging courses for continuing professional education, and maintaining personnel records for payroll and promotion.

The schools focus on the delivery of education and the development of students. The management activities at school level include maintaining student records; school-level examination administration; scheduling classes; management of school facilities, equipment and library resources, and management of teaching and administrative staff. The management of each school is performed by the principal, with the assistance of a vice-principal, school administrator, and a few clerical staff and non-teaching staff. The latter

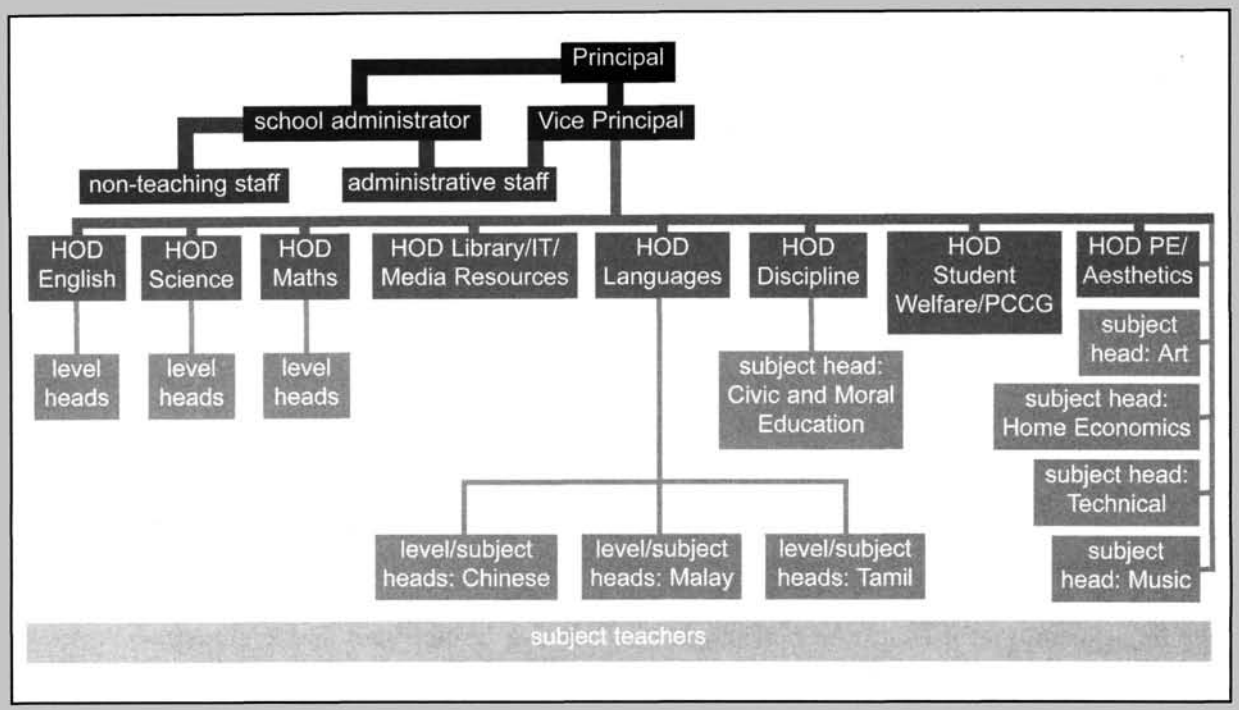

Figure 3.1 The Organisation of Primary Schools in Singapore (may vary from school to school)

provide support in areas such as IT, and in science laboratories. The management of academic content, within the curriculum set by MOE, is performed by heads of departments. The typical management structure of schools is shown in Figures 3.1–3.4.

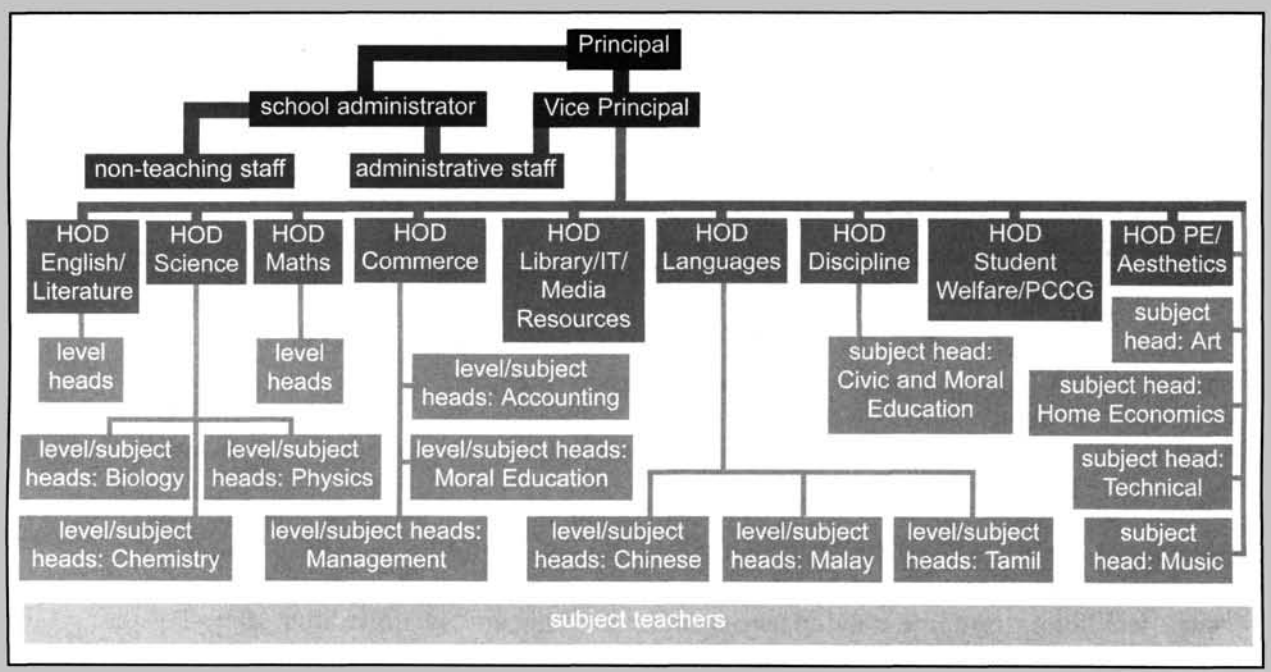

Figure 3.2 The Organisation of Secondary Schools in Singapore (may vary from school to school)

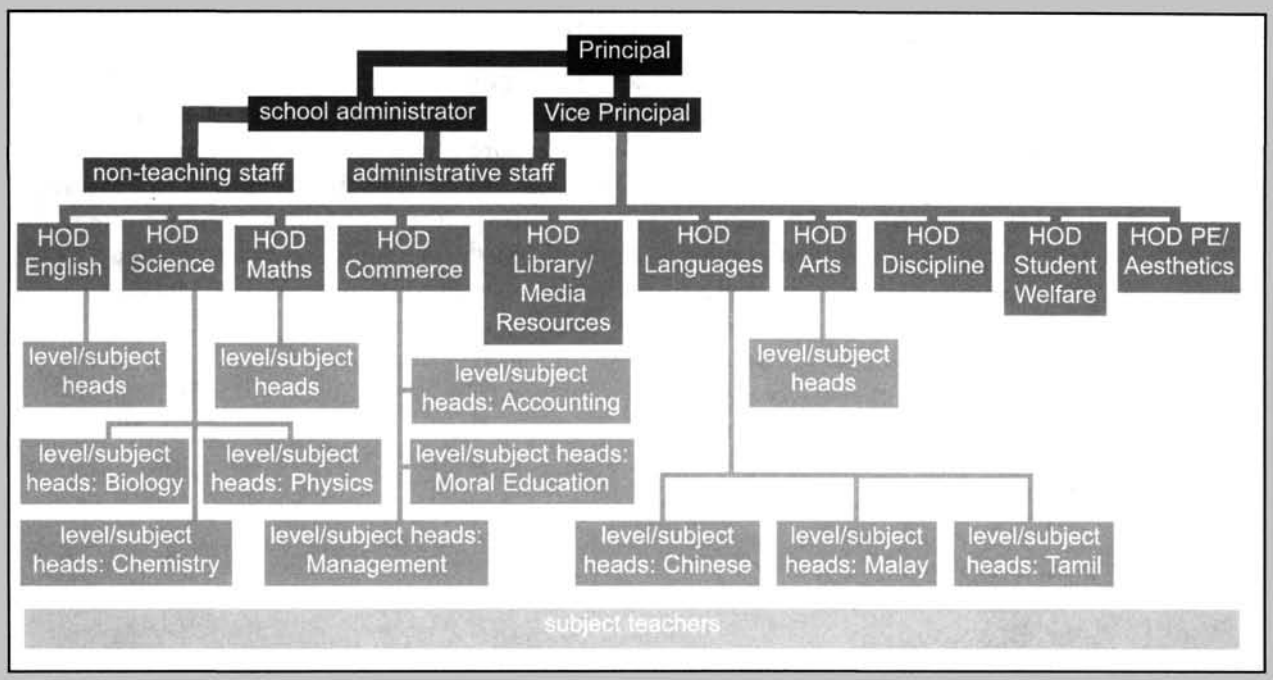

Figure 3.3 The Organisation of Junior Colleges in Singapore (may vary from JC to JC)

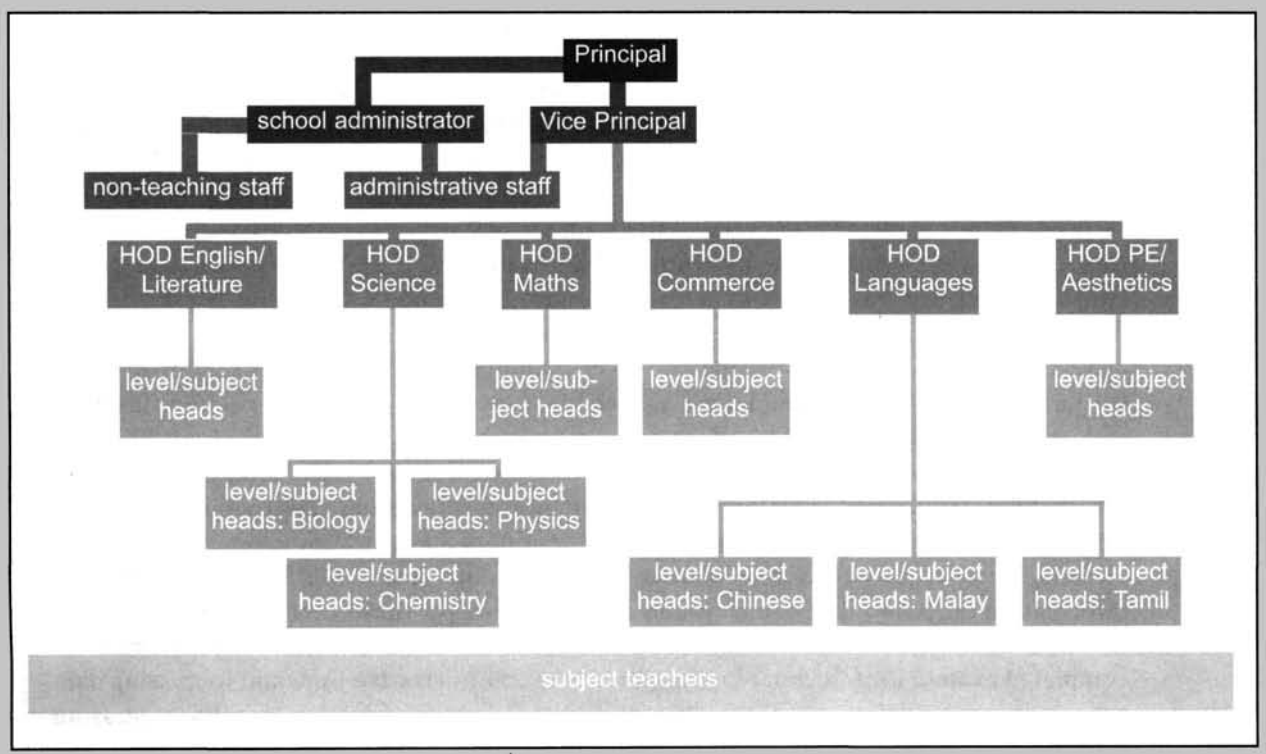

Figure 3.4 The Organisation of Centralised Institutes in Singapore (may vary from CI to CI)

IT Applications for the Management of Education

The centralisation of examinations, student posting, teacher recruitment and personnel data placed a heavy data processing burden on MOE. Computerisation of these areas therefore began in 1979, on a minicomputer platform. The focus was on creating and maintaining data on students, teachers and schools. By 1984 MOE had moved to a mainframe, using the ADABAS database system. Also in the mid-1980s, school systems were developed and installed. These were DOS-based, on stand-alone microcomputers. Most of these have now been replaced with client-server systems linked to MOE.

Today there are over 100 applications in the portfolio of systems supporting the management of education. The majority of these are mainframe systems, with newer applications on the client-server platform. The portfolio of applications can be logically categorised into the following major functional areas:

- examination systems;
- student posting systems;
- personnel systems;
- financial systems; and
- school-level systems.

Each of the categories is presented below in terms of major system functionality and user groups, impacts, training issues and challenges to implementation and operation. Where applicable, plans are outlined for significant new systems.

Examination Systems

MOE examination systems cover the national examinations at the end of primary school, secondary school and junior college/pre-university. The majority of the examination systems are currently mainframe-based and were developed in the 1980s. The systems face the usual legacy system issues such as difficulty of maintenance and lack of proper system documentation. They have therefore undergone a major review and steps to develop new systems have already begun.

Major administrative tasks related to examinations are student registration, examination logistics, and processing of results. The examination system obtains data on all students who are eligible to take the national examination from the MOE student database. This minimises the need for data entry during the examination registration process. For the GCE 'O', 'N' and 'A' level examinations, government school students fill in an OMR (Optical Magnetic Reader) form, which is checked by school teachers and sent to MOE for processing. Private candidates register via the Internet. MOE prints lists of examination candidates and sends them to schools to verify. Examination logistics include nominating examiners and markers, and scheduling classrooms and laboratories for the examinations. Nomination of examiners and markers is done manually at schools, and the information is sent to MOE for data entry. MOE has computerised information on school laboratories, and the scheduling of these is computerised.

MOE examination systems also generate barcode labels for identifying batches of completed examination scripts, saving examiners administrative time and increasing data entry accuracy during the processing of results. The examination results processing systems also update the student database. Results slips and lists are generated and printed at MOE and sent to schools for handing out to students.

The review of the examination systems includes a redesign of the examination administrative process so that all national examinations will follow the same streamlined process. This will allow examination branch personnel at MOE to handle enquiries and tasks across the various national examinations. The redesigned process will include internet registrations for all candidates. One of the main challenges in implementing the new system will be to change the mindset of personnel so that cross-functional work is accepted. Singapore has a unique examination structure, which means that no suitable package application can be found, and a vendor will have to develop the system. Where possible, however, packages will be incorporated. For example, the new examination system will incorporate a software package for examination scheduling.

Posting Students to Schools

Major posting exercises are conducted each year for children entering Primary 1, Secondary 1, junior colleges, polytechnics and institutes of education (ITE). Primary 1 registration and posting involves over 40,000 students each year. The process has been computerised so that very little data entry is required when teachers register each child at the school. Teachers need only enter the child's birth certificate number, and all personal particulars of the child are retrieved from a centralised on-line file created from data on the year's cohort of six-year-olds. This data is obtained from the Ministry of Home Affairs. Registration is done in phases, the early phases being reserved for those with sibling, old-boy and other ties to the school, and proximity to home.

Computerisation has provided significant benefits to parents, who need only make one quick visit to a school to register their child. The number of vacancies in each school is determined quickly and posted on the MOE web site within a day or two after each phase. This information is eagerly sought by parents who have not yet secured a place for their child in the school of their choice, as it helps them to estimate the likelihood of enrolling their child in a later registration phase. A further advantage is that school administrators no longer have to physically transport the registration data to MOE for processing at the end of each registration day.

MOE posts primary school students to secondary schools based on their PSLE examination results (obtained in computerised form from the examinations system) and their preferences for various secondary schools. Students indicate their preferences for up to six secondary schools on a manual form; teachers verify then enter this information on-line. Data entry effort is minimised because relevant student information is retrieved on-line from MOE during the data entry process.

Secondary students who have taken the GCE examinations indicate their preferences for specific junior colleges, polytechnics and ITEs. They are given the option of entering their preferences on-line to MOE via the internet, or submitting the information to their teachers who will enter it for them. Results of the posting are printed by MOE and sent to schools to hand to students. The posting results can also be accessed via the internet.

Teacher training requirements have been low because these systems are easy to use. For the Primary 1 registration system, two teachers per school were nominated to attend an MOE half-day, hands-on training course prior to the rollout. In subsequent years, only briefings were necessary. For the posting systems to Secondary 1, junior colleges, polytechnics and ITEs, no hands-on training was necessary as the systems were simple data entry screens, and the teachers did not have to interact with the public during data entry. Any queries could be handled by calling the help-desk.

The major challenges for these on-line posting systems were to provide sufficient line and processing capacity to ensure acceptable response times at schools during registration periods. This is critical for Primary 1 registration which requires the presence of parents. The response time issue was handled by giving the registration and posting systems priority in use of network and processing resources. Back-up plans were made in case line-drop problems occurred. For the launch of internet applications for posting, MOE assessment of usage based on the size of the student cohort led it to lease the use of a commercial internet provider's server for the duration of the posting exercise.

Personnel Systems

All personnel systems reside on the mainframe at MOE. At the heart of these systems is the teacher data bank containing information about teachers from the point of recruitment onwards. It includes data on qualifications, work experience, and staff confidential evaluations. The main systems that access and update the teacher data bank are the appointment systems for new employees; the teacher posting system that posts teachers to schools, and the confirmation and bar systems which process teacher promotions. The personnel system interfaces with the government-wide system for payroll processing.

At present, data is input to these systems at MOE. For example, when a teacher graduates from training at the National Institute of Education, a manual form is raised, and sent to MOE for data entry to create a new record for the teacher. Subsequently, whenever a teacher is posted to a different school, a form is raised for MOE data entry to update the teacher's record. When a teacher takes a course, the school submits an occurrence form to MOE to update the teacher's training record. Challenges of the current systems are heavy data entry load; complexities in update from multiple sources, and synchronisation of the database.

However, the personnel systems have resulted in a very rich teacher database. Routine and management reports are prepared from data extracted from this database, for MOE decision-makers. For example, the annual exercise of posting teachers to schools uses data such as the teacher's qualifications, experience and place of residence. (The last helps MOE to place teachers in schools near their homes where possible.) Management reviews of teacher-student complement, which assess whether schools have an acceptable student-teacher ratio, also draw data from the teacher database and combine it with data from the student database.

A major review is planned for personnel systems in the latter part of 1998. There are already plans to provide schools with on-line access to training systems, and to relieve teacher management systems. The on-line training system will be an intranet system that teachers can access even from home. It will allow them to plan their individual training, which will be approved by supervisory staff. The systems will also provide course directories that teachers can access. Teachers will be able to nominate themselves for courses, and their nominations will be routed by the system to supervisory staff for approval. Teachers will also be able to provide feedback on the training they receive. Training co-ordinators in each school will also use the system to provide consolidated training plans and records for the school as a whole.

The other school-level personnel system is for managing relief teachers. Relief teachers are often engaged directly by schools, hence school administrators require on-line access to the relief teacher management system to input personnel data for payroll processing.

Financial Systems

A major new system recently implemented in all schools is the Integrated Financial Accounting and Administrative System (IFAAS). This system is on the client-server platform and provides schools with on-line access to MOE. The client application at the school level is used by school administrators to prepare budgets, and to post purchase orders and collections of miscellaneous fees. IFAAS also serves the various departments at MOE, who use it for budgeting, raising purchase orders, and initiating payments. The MOE finance department uses IFAAS to consolidate the budget, to process payments centrally for all schools and MOE departments, and to check school and MOE departmental expenditure against budgets. The system also interfaces with the Ministry of Finance.

One major impact of this system has been the centralisation of payments processing, resulting in much faster issuance of cheques to suppliers. In addition, wherever possible, suppliers are paid via electronic funds transfer. All schools' power and telecommunications bills are also paid electronically. The system has reduced payment-related administrative work in schools.

The training of users for this system was a challenge because there were about five users in each of the 360 schools, as well as 200 users at MOE. The users at the school level were the principal, school administrator and clerks. Each user was provided with two days hands-on training, conducted by a vendor engaged by MOE. Training focused not only on system use, but on basic financial and budgeting concepts. Another challenge was installation of the client application in all 360 schools, which required significant IT manpower.

School-Level Systems

Since 1986 schools have had stand-alone, DOS-based microcomputer administration systems for capturing student data and managing the library. These have been replaced by a new suite of school-level applications which are Windows-based, and which allow direct data transfer between schools and MOE. This is possible because all schools now have at least an administration local area network with five microcomputers, and a leased line link to MOE. All schools also have internet access and internet accounts for teachers. Efforts are under way to upgrade the IT infrastructure at schools for both instructional and administrative purposes. These will be discussed below (page 101, The Master Plan for IT in Education). The new school-level systems are:

- student management systems: All student data is sent on-line to the school once the students have been posted to the school. From then on, the school keeps the student records updated with information such as classes, extra-curricular activities and examination results. The system also enables teachers to capture and print examination results slips. The student management system periodically transfers data up to MOE to update the central student database.
- student profiling system: For use in pastoral care and career guidance, it also stores student profiles with information on academic performance and extra-curricular activities, and family background. Counselling and interview notes can also be stored in the profiles.
- physical fitness testing: Stores and analyses students' height, weight and physical fitness test data.

These systems were implemented in 1997, and are relatively new. Initial impacts include more timely data transfer about students between schools and MOE, although some teachers find data entry difficult as they are not comfortable with microcomputers.

User training during the rollout of the systems to schools was heavy because all teachers needed to interact with the student management systems. MOE is attempting to alleviate the on-going training burden by disseminating a user guide and FAQs (frequently asked questions) on the MOE-schools intranet.

Some challenges arose initially during the rollout because the systems assume a standard process at schools. However, schools have some discretion when implementing various MOE guidelines and this sometimes results in differing processes at schools.

This section has provided a functional view of the key systems in education management, and system-specific discussion of impacts, user training and challenges. The following sections will give an overview of key training and support issues, and impacts.

User Training and Support

One clear implication of the move to on-line access for schools is the increase in the number of users who have to be trained. For mainframe systems with no on-line access by schools, only a small number of MOE users needed to be trained. However, the number of users increases dramatically when the systems are rolled out to schools, as with the school-level student management system, and the Integrated Financial Accounting and Administrative System. MOE has dealt with the increased training burden in a number of ways:

- out-sourcing training to the vendor;
- making user interfaces as easy as possible, so that minimal or no user training is required. This was possible for the primary registration system, and the GCE student posting systems for selection of school preferences;
- planning to move towards web-based training, making training material available on the intranet;
- having on-site technical assistants at each primary school, and access to help-desk support for secondary schools. The help-desk is operated by a vendor that MOE has appointed to provide support to schools. The on-site technical assistants are also employees of the vendor. MOE initially provides some applications-specific training to the technical assistants, but the vendor is responsible for ensuring that the knowledge is subsequently transmitted to new vendor employees.

In addition to the application-specific training for the relevant users each time a new system is rolled out, MOE provided all 23,000 teachers with two days of basic training in Word and internet. A smaller number of teachers received additional training in Excel and PowerPoint. The training was done by vendors and took about a year.

The Major Impacts of IT

The major impacts of the use of IT for education management are efficiency and accuracy; convenience for users, and better information for decision-making and planning. These are summarised, with examples, in Table 3.3.

Table 3.3 The Major Impacts of IT Systems for Management of Education in Singapore

Functional Category	*Major System Impacts*
Examination systems	**Efficiency and accuracy:** • Minimises data entry of student particulars • Accurate processing of examination results • Generation of results slips for schools **Convenience:** • Any time, anywhere, internet registration for GCE examinations • On-line access to results for private candidates
Student posting systems	**Efficiency and accuracy:** • Minimises data entry of student particulars • Sharply reduced Primary 1 registration time for parents • No need for principals to transport Primary 1 registration data to MOE at the end of each phase • Greater accuracy in matching students' school preferences with eligibility as determined by results **Convenience:** • Any time, anywhere, internet selection of students' school preferences • On-line access to results of posting
Personnel systems	**Better information for decision-making:** • Teacher database provides information for posting and promotions, as well as for policy-making • Intranet teacher training system supports individual training, road-map planning, course nomination and evaluation
Financial systems	**Efficiency and accuracy:** • Less payment administration at schools, due to computerisation and centralisation of payment processing • Faster payment settlement with less labour due to electronic funds transfer
School-level systems	**Better information for decision-making:** • More up-to-date student information captured at schools, and updated at MOE • Easily accessible student information available, for pastoral care and career counselling **Efficiency and accuracy:** • Minimises data entry of student data at schools and HQ

Time and labour savings arise from providing schools with on-line access to MOE data. This removes the need for a great deal of manual recording of data. School administra-

tors and teachers usually need only to verify the student data retrieved on-line and to input only minimal additional update data. MOE staff are also relieved of data entry when schools are given access to update school, teacher and student data themselves.

Convenience for school staff, students and parents is also evident from systems that have moved on-line. Intranet and internet-based systems in particular provide users with any time, anywhere access.

Finally, the rich computer databases that have been built up on students, teachers and schools provide timely and comprehensive information for MOE decision-makers, as well as for school principals and senior school administrators.

Future Directions: The Master Plan for IT in Education

Recently implemented systems and planned systems clearly show the following trends:

- on-line information access and update, providing users (school staff, students and parents) with anytime, anywhere access to relevant data such as school postings and examination results;
- use of client-server, internet and intranet platforms;
- electronic funds payment for schools and MOE expenses, and collection of fees;
- streamlining and standardising administrative processes with the help of IT; and
- web-based training and user support.

The Master Plan for IT in Education, which was approved in early 1997, will provide a further boost to these trends. The Master Plan is focused primarily on establishing IT-based teaching and learning in schools. However, the human and physical infrastructure that will be put in place to promote learning objectives will have a positive spill-over effect on education management and administration also.

In terms of human infrastructure, the plan will require teachers to use educational software in teaching, and to access web sites for educational content. This will pave the way for launching computer applications in more areas of education management, particularly those that can be deployed using web-based technology. The plan foresees that internal e-mail will be the dominant mode of communication between MOE and schools, and among teachers in various schools. To achieve this, a comprehensive training plan is in place with heads of departments and selected teachers being trained, and they in turn will train other teachers.

The number of microcomputers in schools is being increased so that primary schools will have a student to computer ratio of 6.6 to 1, and secondary schools and junior colleges will have a ratio of 5 to 1. The ready access to computers in schools will allow students to do more data entry themselves, for example examination registration. All students from Primary 4 and above will have internet accounts. Teachers will have notebooks, and this computing portability will open up new ways to access and update information any time, anywhere. All schools will receive whole-school networks, which will be linked to a wide area network. This, in turn, will be connected eventually to a high-speed national backbone.

The Master Plan for IT in Education is a blueprint for the integration of IT in education. Twenty-two demo schools have already been provided with the physical infrastructure and training, and have begun to experiment with the use of IT throughout the curriculum. The rollout to all schools is scheduled for completion in 2002. It is a serious and ambitious effort to enrich the learning environment; encourage creative thinking; innovate pedagogy, and promote administrative and management excellence. The use of IT for management education, as reviewed in this case study, will be continually reviewed and renewed as the Master Plan unfolds in the next five years.

Note

I should like to thank the IT personnel at MOE who participated in the preparation of this case study. They contributed their time and their considerable knowledge of IT use in the Singapore education system.