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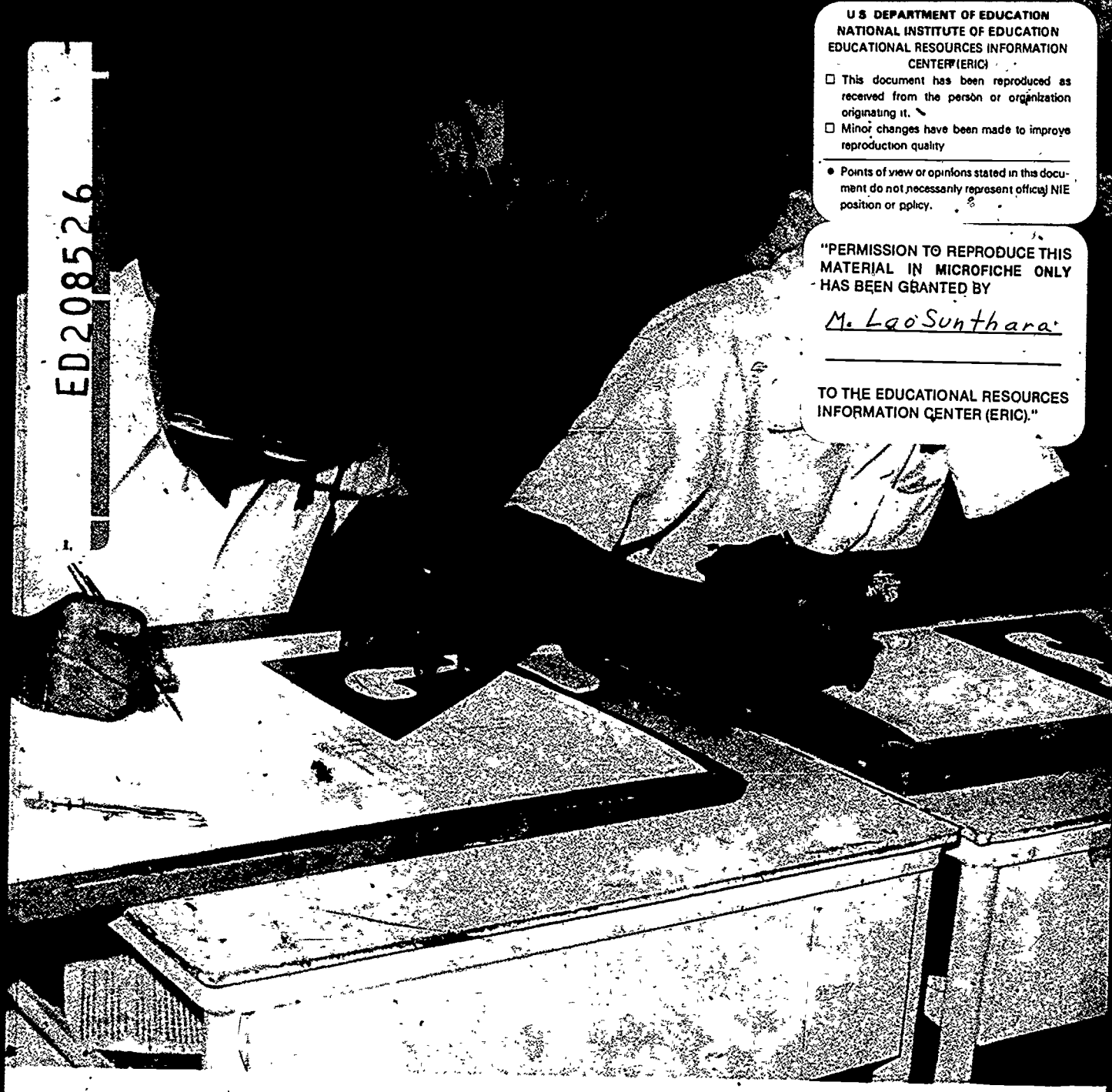
ABSTRACT

Land scarcity dominates the thinking of school planners in Singapore. Techniques for optimizing the use of land for schools include (1) the construction of multi-storied or high-rise schools; (2) operation of a double-shift system and, in some cases, a triple-shift system; (3) multiple use of educational spaces; and (4) construction of several schools in combination on the same site. This case study of the design of secondary schools in Singapore includes a review of the curriculum and explains how this has been translated into spacial requirements, building layout, and site layout. Methods of school mapping (planning the location of new schools to provide maximum service) are explained. An organizational chart shows the government departments and statutory boards that are involved in planning and building schools. Illustrations show the layout of science laboratories, home economics laboratories, workshops, craft rooms, resource centers, canteens, and sports facilities. The report concludes with a chapter on construction costs. (Author/MLF)



The design of secondary schools

~a case study, Singapore

EDUCATIONAL BUILDING REPORT
UNESCO REGIONAL OFFICE FOR EDUCATION IN ASIA AND THE PACIFIC
BANGKOK, THAILAND

17

Liew Kok-Pun, Michael

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ABSTRACT

Monograph: a case study on experience in Singapore on the design of secondary schools, most of which are multiple-shift schools. Includes a review of the curriculum and explains how this has been translated into space requirements, building layout and site layout. Illustrations show the layout of science laboratories, home economics laboratories, workshops, craft rooms, resource centres, canteens and sports facilities. The report concludes with a chapter on construction costs.

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EDUCATIONAL BUILDING REPORT 17

The design of secondary schools

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by Michael Liew Kok-Pun
Pang Kia Seng
Harbans Singh

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PREFACE

In the field of school building there is a wide diversity of school designs, school furniture, construction methods and materials used. This is unavoidable for climatic, economic, social, cultural, educational and other reasons. In view of this, school building that is found suitable in one country may be quite unsuitable for another. Nevertheless, despite this diversity of circumstances, there are many aspects of school design which are common to most countries in the region of Asia and Oceania.

It was with this in mind that the authors adopted a case study approach in the preparation of this publication. Two main elements, namely the functionality of the school building and the constraint of land, dominate the thinking of educational planners, physical planners and architects in the design of secondary school buildings in the Republic of Singapore. These two elements are clearly reflected in the design and multiple use of educational spaces provided in the standard secondary school.

As a sketch or photograph gives a more comprehensive and complete representation of the design and internal layout of various education spaces than do verbal descriptions, the writers have made extensive use of relevant sketches and photographs coupled with the usual descriptive approach.

Chapter One

AN OVERVIEW: PLANNING AND BUILDING OF NEW SCHOOLS IN SINGAPORE

Background

Wide variations existed in size, facilities provided and architectural design of schools built in Singapore prior to 1950. Some schools, particularly in the villages, were not purpose-built but were adapted for educational purposes. It is not surprising, therefore, to find quite a few schools functioning in the premises of temples or even on the stages of village theatres. This variation could be attributed to the policy of the colonial government in avoiding a substantial commitment to the provision of education and also in confining their felt obligation to the indigenous Malays. One consequence of this was that it fell upon the Chinese and Indian communities to provide their own schools.[1] As a result of this policy and also arising from the absence of any form of effective, central planning and co-ordination in school buildings and educational development, there mushroomed all over the island a large number of small schools which were built and operated by private bodies. According to one report[2] there were as many as 271 registered schools in 1949.

This situation prevailed until 1950. From 1950 to 1959 the colonial government formulated and implemented the first planned school building programme with a target of building five schools annually for a ten-year period. A standard school building plan was used. Schools built during this period were simple in design and economical to construct. Each has 14 classrooms, a principal's office, a staff room and sanitary accommodation.[3] Line drawings of the front elevation and section are shown in Figure 1.

With the attainment of self-government in 1959, the Government assumed responsibility for building a sufficient number of schools to ensure that every child of school-going age had a place in school. A planned programme of construction of school building was prepared. Recent statistics show that since 1959 a total of 72 primary schools and 55 secondary schools have been built. The 1975-1980 School Building Programme was for a total of 66 new schools (36 primary and 30 secondary schools). These schools are based on approved norms for different types of educational spaces. The same standards are also

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1. Colony of Singapore. Department of Education. *Annual report, 1947.* Singapore, Government Printing Office, 1948.
2. _____. _____. *Annual report, 1948.* Singapore, Government Printing Office, 1949.
3. _____. _____. *Annual report, 1952.* Singapore, Government Printing Office, 1953.

applicable to non-governmental schools although the design of these schools need not be identical to the standard model. The layout plan of the Public Works Department (PWD) 1965 design of secondary schools is given in Figure 2. More recent designs (PWD 1974 Model) will be discussed in Chapter Three.

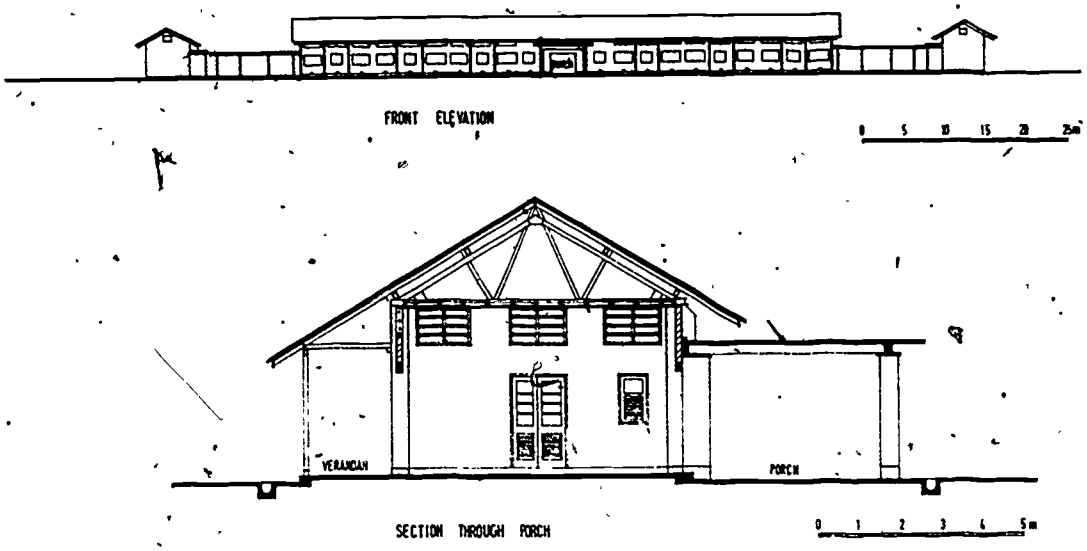

Figure 1. Standard primary school (1950 design)

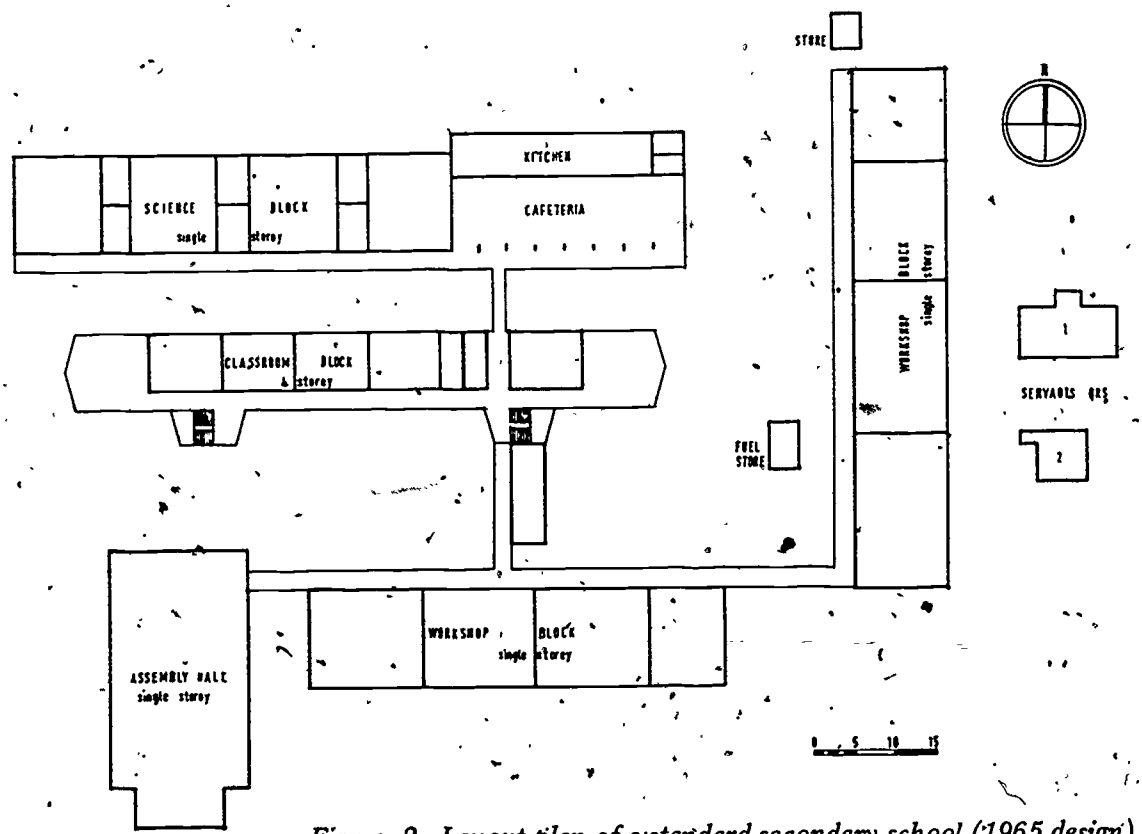

Figure 2. Layout plan of a standard secondary school (1965 design)

Theoretical framework

School building cannot be considered in isolation, but must be related to six interdependent elements. These six elements, all of which exert their impact on the design and construction of school buildings, are identified as follows:

1. Curriculum content and teaching methods;
2. Structure of the education system;
3. Costs;
4. Politics and education;
5. Use of school buildings; and
6. School building design.[4]

Another critical element omitted from the hexagonal model above, however, is the element of land constraint. This seventh element could be considered as decisive in the design and construction of school buildings in countries where land is a scarce and expensive commodity. Singapore and Hong Kong provide two classic examples of the inter-relationship between land constraint and school design, as will be shown in the next section.

The way these seven variables interact differs from country to country but all seven elements are always present. Some of them operate to influence the thinking of planners and administrators, while others, usually at the operational level, influence the thinking of those concerned with environment, in particular the architects. In the ultimate analysis, however, it is imperative to ensure that school buildings, designed and constructed with due consideration given to these seven elements, are functional. A functional school plant is one which facilitates the educational experience. Davis summarizes this aptly as follows: ". . . the curriculum finds its physical expression in the construction and organization of the school plant. Stated in another way, the functional school plant is a spatial interpretation in wood, steel, stone, bricks, glass and concrete of the education programme."[5]

Land constraint and optimization

Within the physical constraint of 616 sq. km[6] and with a population of about 2.35 million, Singapore has the doubtful distinction of being one of the most densely-populated countries in the world, with an average of about 3,815 persons per sq. km. This proportion is fairly close to that of Hong

4. Asian Regional Institute for School Building Research. *Educational building space and cost norms for the educational planner* by D.J. Vickery, Colombo, 1971.

5. Davis, J. Clark. *The principal's guide to educational facilities.* New York, Charles E. Merrill Publishing Company, 1973.

6. Singapore's total land area of 616 sq. km. is largely spread over its main island, with some 40 sq. km. of it scattered over 60 off-shore islands. These are handicapped, functionally, by the absence of self-supporting water supply and problems of communication.

Kong, a highly urbanized area, which has an average of more than 3,860 persons per sq. km. It is therefore not surprising that at least 160 sq. km. on the main island of Singapore are built-up. Land reclamation is pursued in earnest. So far, some 30 sq. km have been reclaimed and considerably more are either being reclaimed or are planned for reclamation.[7]

Optimum use of land resources thus constitutes an important element in physical planning and has priority in land-use policy decisions. The following main factors have been identified as influencing the direction this optimization process takes:

1. Physical heritage and geology;
2. Economical environmental considerations;
3. Multiple use; and
4. Complementarity and compatibility.

In planning for new schools in Singapore, the last three factors have greatly influenced the thinking of educational planners and architects concerning the design of school buildings. The architectural solution to the shortage of land in Singapore, as is the case in Hong Kong and other densely-populated cities in the world, is to construct multi-storied or high-rise schools. In the present context, a high-rise school is defined as a school of more than four storeys. Singapore experimented with its first high-rise school in 1960. A ten-storey primary school (Selegie School) was built on a 0.364 ha site, thereby giving a saving of 1.053 ha, compared with the standard primary school with a site area of 1.417 ha. An example of a multi-storey school in Singapore is shown in Figure 3.

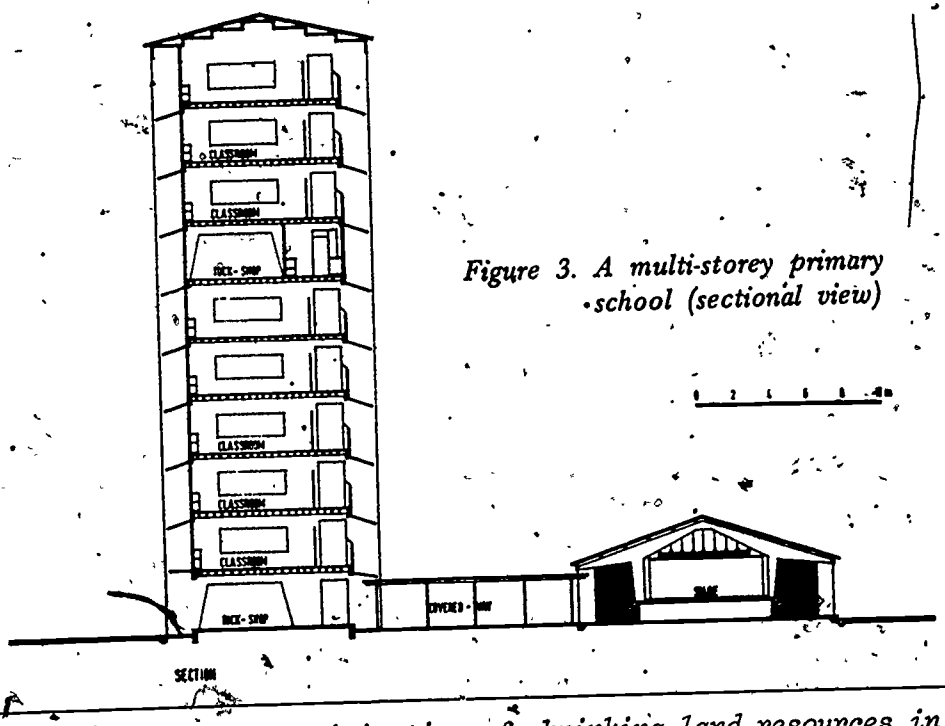

Figure 3. A multi-storey primary school (sectional view)

7. Chua Peng Chye, *The optimization of shrinking land resources in Singapore*, Singapore Institute of Planners (SIP) Journal, Vol. 4, no. 1, pp. 2-7.

In Singapore where multi-storey housing is accepted as the reasonable solution for living, there appears to be no logical quantitative argument against multi-storey schools. There is a tacit acknowledgement of the fact that, in most densely populated cities, new school buildings have to be located on increasingly smaller sites. There is in any case a tendency to increase the number of storeys in schools to make the best possible use of available land.

However, high-rise school building brings to the surface many administrative problems. In a case study of the high-rise Selegie School in Singapore, the following were identified:

1. The critical problem of circulation, especially vertical circulation;
2. Inadequate open space about the school for recreational and physical educational activities; and
3. Lack of provision for flexibility in the school.

The study concluded that, except for the above problems, multi-storey schools like Selegie School are functional.[8]

Multiple use of educational spaces within school buildings in Singapore is obtained in several ways. The most obvious example is operation of the school-plant on a double-shift system and, in some cases, a triple-shift system, with lessons being conducted throughout the day on a two-session basis and, thereafter, evening adult-education classes held through the night. Another example of multiple use of educational spaces is to be found with certain facilities such as the school hall which also serves as a canteen; the school car park which is sometimes used as a parade ground; and the secondary school hall which, in addition to being used for school assemblies, also provides space for indoor badminton.

Yet another method of optimizing the use of land for new schools practised in Singapore is by building several schools in combination on the same site. The school field, which is an indispensable element of a school site and which takes up a substantial portion of land, can in this way be shared by all the schools on the site. To illustrate this, Table 1 shows the standards of sites for schools built singly and in combination and the savings in land for schools built in combination (ps denotes primary school; ss denotes secondary school). Figures 4-8 show the layout plans of several possible combinations of schools.

Table 1. Comparison of standards for school sites

Combinations of schools	Standard (in ha)	Saving (in ha)
1 ps	1.417	-
1 ss	3.036	-
1 ps + 1 ss	3.644	0.809
2 ps	2.632	0.202
2 ss	4.251	1.821
2 ps + 1 ss	4.251	1.619

8. Asian Regional Institute for School Building Research. *High rise schools: a case study* by Atelier Akitek. Singapore, Eurasia Press, 1969.

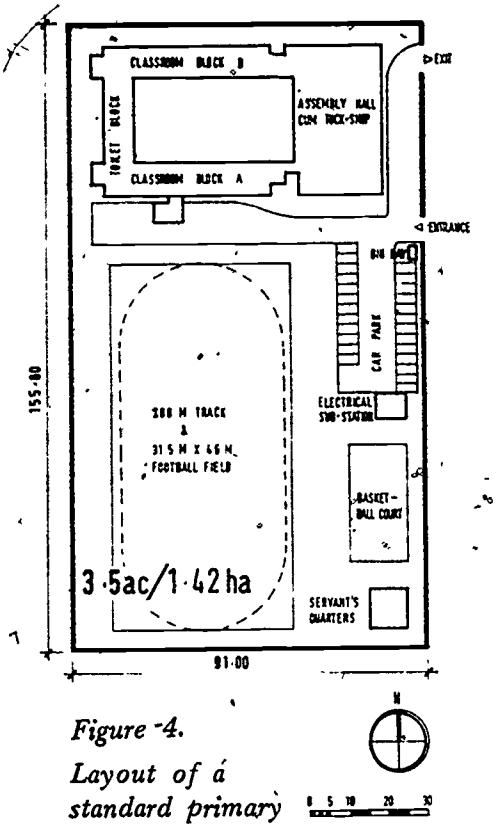

Figure 4. Layout of a standard primary school

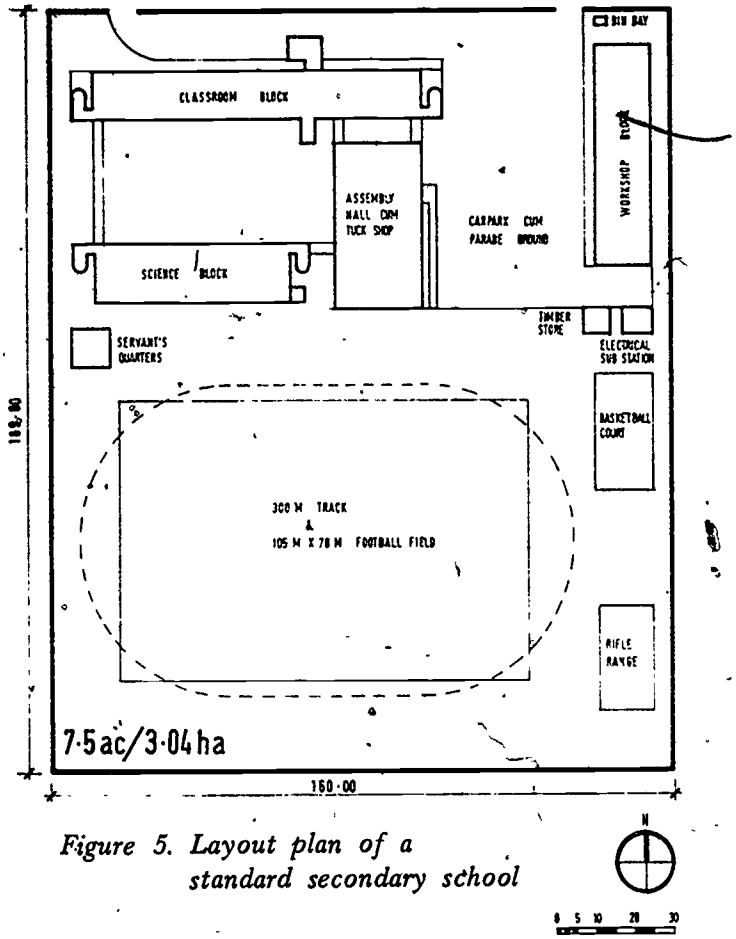

Figure 5. Layout plan of a standard secondary school

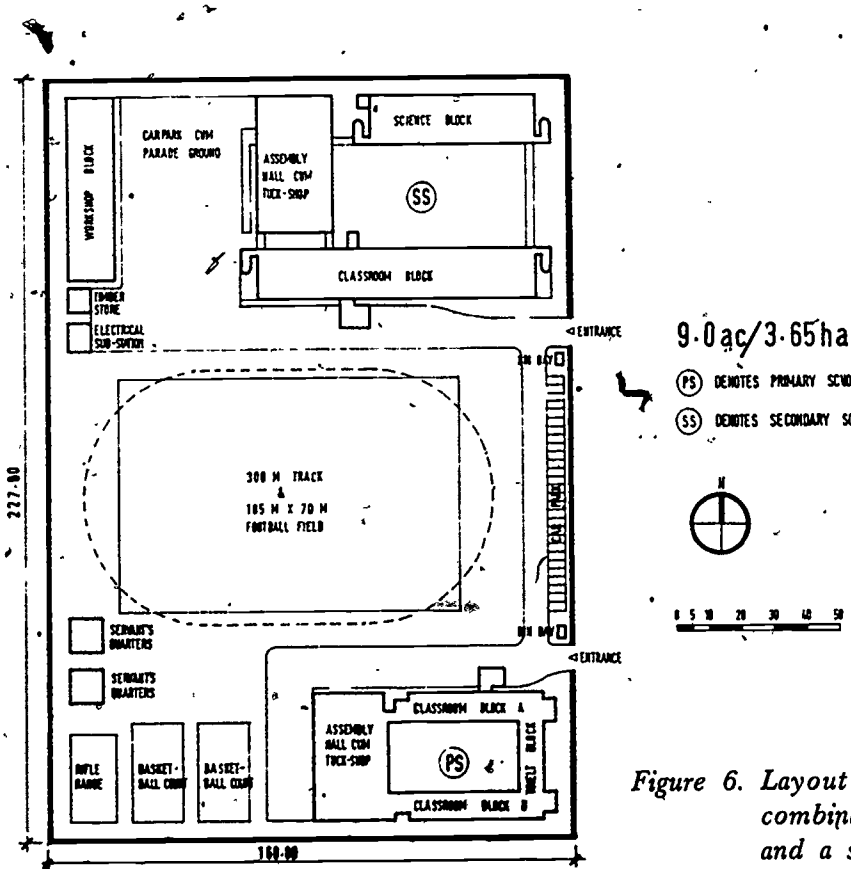

Figure 6. Layout plan for a combination of a primary and a secondary school

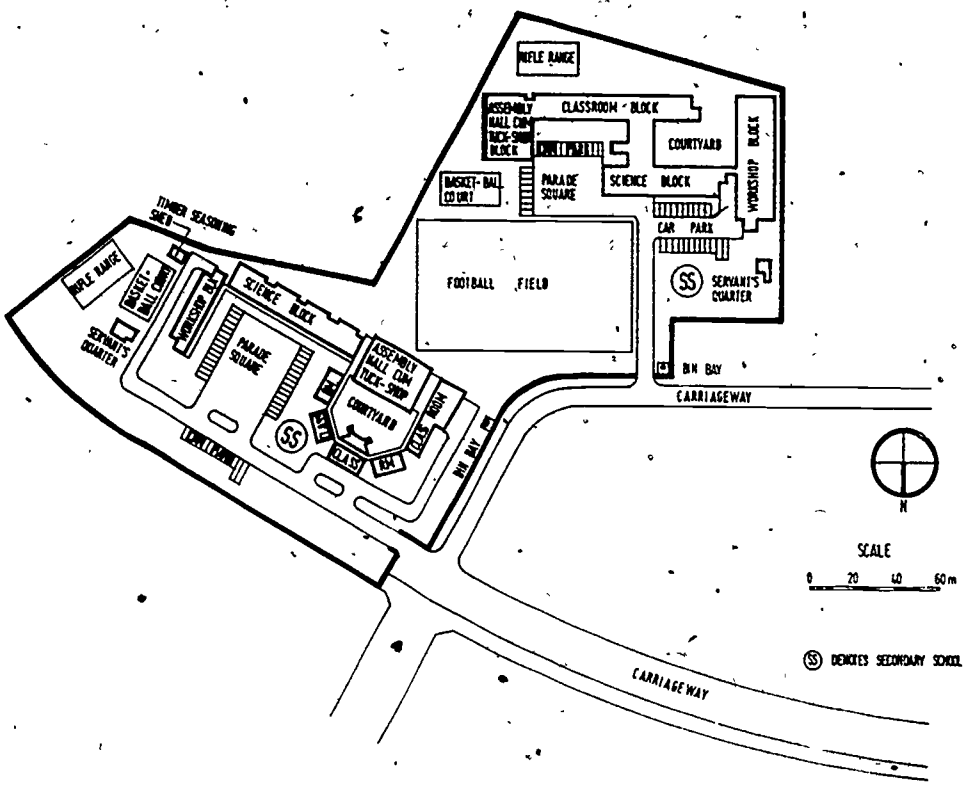

Figure 7. Site layout plan for a combination of two secondary schools

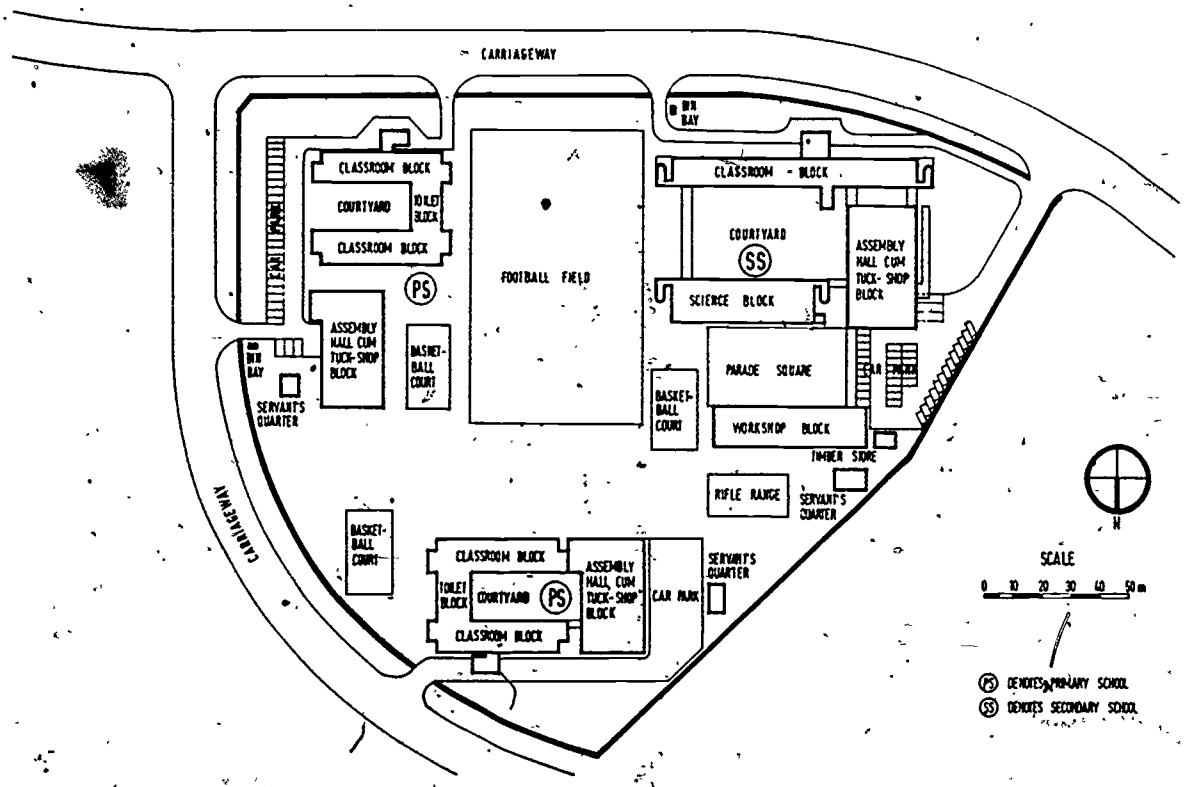

Figure 8. Site layout plan for a combination of two primary schools and one secondary school

In planning public housing in Singapore, the Housing and Development Board (HDB) has adopted the 'neighbourhood principle' which ". . . ensures that each neighbourhood is 'self-sufficient' in that the residents do not have to leave their immediate neighbourhood for much of their day-to-day needs. Commercial, social and recreational facilities as well as employment opportunities are provided within a radius of from one-half to one mile of the residents. In the Singapore context, each neighbourhood consists of about 2,000 to 5,000 households, averaging six persons per household. Each neighbourhood or estate is self-contained in essential facilities and services such as shops, markets, primary and secondary schools, clinics, community centres, sports and recreational amenities. Light industries are also found on the periphery of these housing estates. The emphasis is placed on comprehensive planning geared towards a greater degree of self-sufficiency in the form of new towns ...".[9]

School mapping

Planning the locations of new schools, or school mapping, involves the analysis and rationalization of the spatial organization of the educational system in relation to the supply and demand for schools at the macro and micro levels.

Like all other social provisions for items of physical infrastructure, such as clinics or markets, schools are located to serve a defined catchment area. Such facilities as these are allocated ideally to provide a service of maximum efficiency to the population in the areas. Here the concept of 'efficiency' is defined differently for each service and hence the differing numbers, distributional patterns and capacities of service units. Overall, however, the infrastructure provided is designed to meet the needs of the community. The locational pattern of these facilities would usually correspond to the distribution pattern of population - the larger the population, the greater the need for these provisions. Schools, however, manifest certain unique characteristics that result in their having patterns of provision different from those of other social facilities. The following are some of these characteristics:

1. The clientele is well-defined;
2. The catchment area of schools must be small as the home-school journey is of regular frequency, twice a day, five days per week, and by students who cannot be expected to travel as far as adults; and
3. School sites require more land than many other community facilities, especially for playfields.

The relationship between schools and the population they serve can be considered at several levels. At the macro level the concern is aggregate rather than distributional, and the aim is to ensure that the national supply matches the demand. At the micro level, it is necessary to examine local disparities in provision and enrolments.

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9. Pang Eng Fong and Khoo Hsiao Pi, "Patterns of industrial employment within public housing estates," in *Public housing in Singapore*, ed. by Stephen H.K. Yeh. Singapore, Singapore University Press, 1975, p. 241.

The number and location of schools in any locality would depend on the type of population distribution which could be characterized at being either dispersed or nuclear. In Singapore the population distribution is mainly nuclear as, by the end of this decade, a total of 65 to 70 per cent of Singapore's estimated total population of 2.5 million will be residing in HDB estates.

In the process of analysis[10] to determine location criteria for schools, two twin concepts of threshold and range are used. The threshold is defined as the minimum population the school requires to operate within the established bounds of efficiency. The threshold population (N) for a primary school is given by the relationship: $N = \frac{n}{a}$

where n = capacity of a standard primary school; and

a = percentage of the total population which is of primary, school-going age.

In Singapore, n = 2,240 students, a = 15 per cent (.15); hence N = 14,933 or a population of roundly 15,000. In other words, to justify the construction of a primary school within a certain community, its minimum population should be 15,000.

The range of a school is the range that the students are prepared to travel from their homes. Because of the nature of the journey to school, its regularity and its being undertaken by children, the range of a school is small. In Singapore "primary school children should not have to travel more than 3.2 km to the schools, secondary school students not more than 6.4 km and pre-university students not more than 9.6 km." [11]

The interaction of threshold and range will be one of the considerations in formulating the school map for the area. Ideally, the plan is to match the threshold and the range data to ensure that the number of schools is kept to a minimum, and that each school operates to serve adequately the population surrounding it.

Population change, which comprises two major components - population growth or decline, and population mobility - should also be considered. The impact of population growth and decline on the school network, as on other aspects of education (teacher requirements, costs of education) are sufficiently evident. In Singapore, where there has been a perceptible decline in birth rate during the last few years, there is a cogent need to review the school-building programme.

Population mobility is seen in the internal redistribution of population arising from a massive shift to HDB housing estates, thereby creating a regional disparity in the supply of schools.

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10. See: Hagget, P. *Locational analysis in human geography*. New York, St. Martin Press, 1965.

11. Text of speech by the Prime Minister of Singapore, Mr. Lee Kuan Yew, at the Henderson and Tiong Bahru constituencies. Reported in Straits Times, 13 November 1972.

The education system exists to provide a service to the population - directly to the school-age population and indirectly to the community. It does so through the provision of schools sited at certain locations. The criteria used to determine these locations are:

1. Factors concerning the site; its physical area, size and configuration, and cost; and
2. Factors related to the social and economic environment and particularly to the population the school seeks to serve.

The first issue is left to the Master Plan Committee, and the second is basically determined by the Ministry of Education. Two important additional criteria have to be considered in site selection, namely, distance minimizing, and choice of school.

The distance-minimizing criterion requires schools to be located in such a way that aggregate home-school travelling distance of all pupils is minimized and that all children can, if their parents so wish it, attend school nearest their home. Lee showed that young children who travelled short distances to school were less subject to strain in the classroom.[12] Moreover, the risk of accident is minimized for shorter distances travelled.

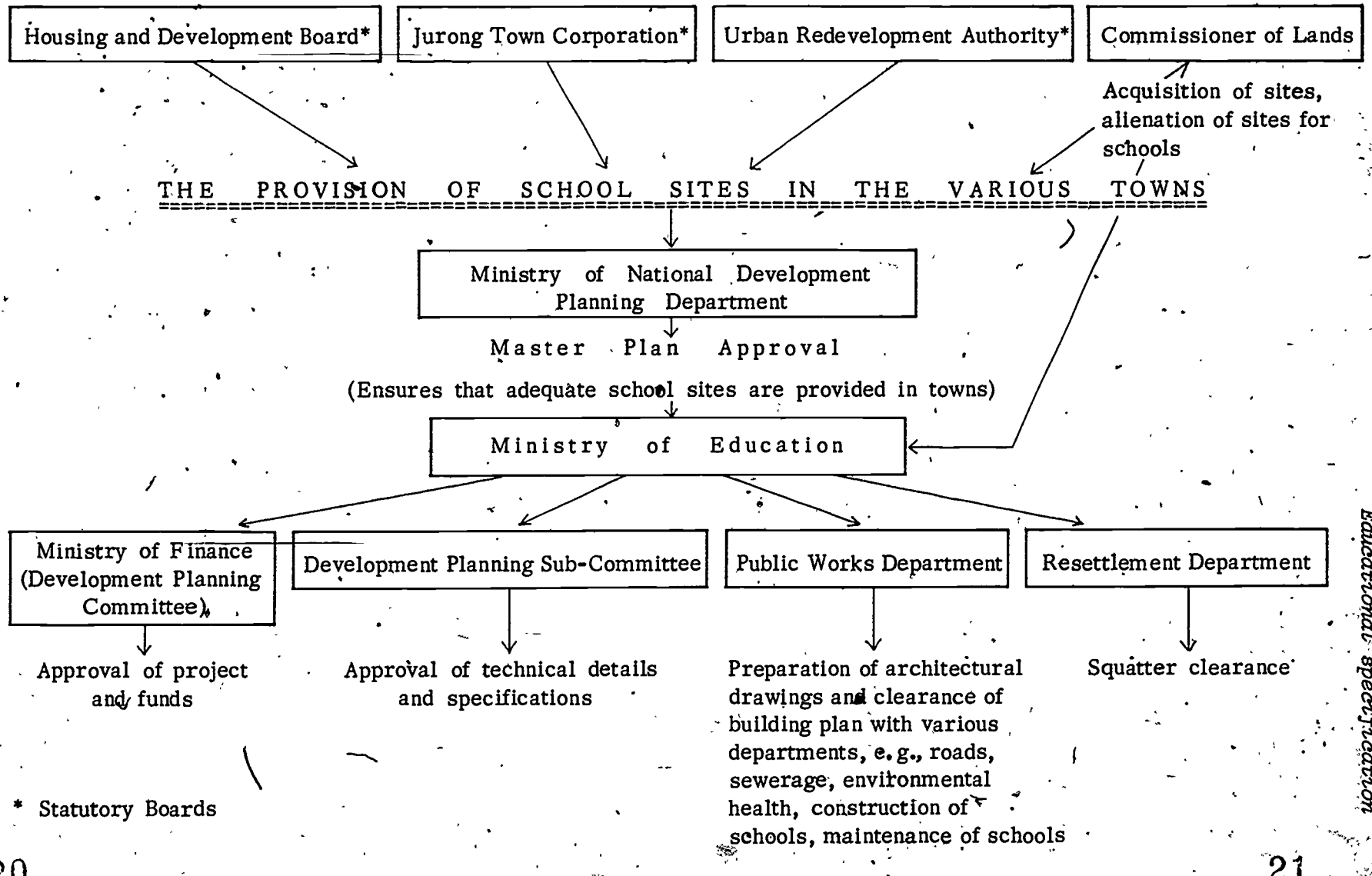
The choice-of-school criterion allows parents to choose schools for their children, and is to a certain extent the existing admissions policy of the Ministry of Education in Singapore.

Institutional arrangement

The institutional arrangement for school building relates essentially to the total period from the initiation of a project through completion of the building and its subsequent evaluation. The processes involved in this have to be viewed in the wider context of forward planning of school-building programmes if implementation is to be effective and resources properly used. In Singapore, the planning and building of schools involve a number of government departments and statutory boards. An organigramme of the various departments involved is given in Table 2.

12: T. Lee, "On the relations between the school journey and social and emotional adjustment in rural infant children", *British journal of educational psychology*, 27(2), pp. 101-104.

Table 2. Organigramme of School Planning and Building Departments



* Statutory Boards

Chapter Two

EDUCATIONAL SPECIFICATION

Preparation

A prelude to the architectural design of a school building is the preparation of the educational specification. Like the blueprint and material specifications, the educational specification gives a detailed description of the school curriculum and teaching methods - in short, a description of all the educational activities that are to take place in the school. To the architect therefore, a school building and its site could also be considered as a translation of the school curriculum into space requirements. The specification of educational needs provides the architect with a concise and comprehensive guide in developing layout plans, sketches and working drawings of the school building and the educational spaces within it.

Usually, a team approach is adopted in the development of the educational specification as school facilities today are more comprehensive and complex than before. The planning team comprises the users of the school building (the school head and his staff), the physical planners and officers of the Ministry of Education, and the architect, engineers and quantity surveyors of the Public Works Department (PWD). There should be a continuing dialogue and exchange of ideas between the educator and the architect as the educational specification is transposed into architectural plans and the building specification.

As a guide, the educational specification includes the following information and data:

1. School curriculum in terms of its philosophy and objectives;
2. Subjects taught and the time allotted to each subject;
3. Time-tabling and scheduling patterns of educational spaces;
4. Groupings or settings of students;
5. Space relationships;
6. Internal fixtures and fittings for educational spaces;
7. Furniture and equipment requirements for each instructional area;
8. Acoustical, thermal and visual settings;
9. The type and amount of permanent equipment used in the different instructional areas;
10. The type and amount of movable equipment used in the different instructional areas;
11. Materials that need to be stored in teaching and learning areas;
12. Flow pattern of student movements; and
13. Cost per place or cost per unit area.

It is most helpful to include in the specification a sketch of each learning area in the school. These sketches need not be developed in any great detail. Sketches showing the instructional/spatial/area relationships can be useful to the architect, as follows:

1. Layout plan of school indicating the spatial relationships of the various instructional areas;
2. Student work-space including the locations and placement of furniture for students and teachers, instructional materials (such as blackboards, various projectors, globes, models and charts) and storage space.

Objectives of education

The standard secondary school in Singapore houses a four-year educational programme for Secondary 1-4 (grades VII-X) students within the 12-16-year age range. The objectives of education in Singapore are as follows:

> "Education in Singapore seeks to develop to the fullest extent the potentialities of the individual as well as to ensure the collective welfare of the society. In particular, it aims to instil a love of freedom, truth, and justice, respect for fundamental human rights, acceptance of the democratic way of life and appreciation of racial and religious tolerance. It seeks to inculcate habits and attitudes leading to the development of adaptability, creativity, social responsibility and loyalty to the Republic. It endeavours to provide the knowledge and skills necessary for the economic development of the country." [1]

Secondary school curriculum

Secondary education in Singapore provides a four-year educational programme of general education leading to the Singapore-Cambridge General Certificate of Education (Ordinary Level) examination. A common curriculum is offered in the first two years of secondary education. There is a core of eight subjects common to the normal, express and special courses. In addition there are four non-examination subjects. In the third and fourth years a diversified curriculum enables students to specialize by selecting subjects (in addition to the core curriculum) which are biased towards science, arts, commerce or technical education. The lower secondary curriculum is given in Table 3. The third- and fourth-year secondary school curriculum is given in Table 4.

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1. Ministry of Education, Singapore. *Education in Singapore*. Singapore, Educational Publications Bureau, 1972.

Table 3. Secondary I and II curricula

Subjects	No. of periods* per week
First language and literature	8
Second language	6
Elementary mathematics	5
General science	6
History	2
Geography	2
Art and crafts	2
Technical subjects (metalwork/woodwork) or Home economics (for girls)	3
Non-examination subjects	
Moral education	2
Physical education	2
Singing	1
Assembly	1
	40

* Each period is 35-40 minutes

Instructional and learning areas

To offer an educational programme of such scope, it is necessary to provide a cluster of highly-specialized instructional spaces. The following major clusters are required:

1. Instructional and learning area

   classrooms,
   special rooms for library, music and audio-visual aids/educational television programmes,
   science laboratories,
   technical workshops,
   home economics rooms,
   art and crafts rooms,
   school hall,
   physical education facilities including the playing field, basketball courts and indoor badminton courts, and
   parade square.

2. Administrative spaces

   principal's office,
   general office,
   staff room, and
   office space for uniformed group organizations.

Table 4. Secondary III and IV curricula

Technical Stream			Non-Technical Stream		
Subjects	Periods per week	Remarks	Subjects	Periods per week	Remarks
A. Compulsory examination subjects	26		A. Compulsory examination subjects	26	
1. First language			1. First language		
2. Second language			2. Second language		
3. Elementary mathematics			3. Elementary mathematics		
4. Physical science			4. A science subject or home economics		
5. Technical drawing			5. Literature of history or geography		
B. Compulsory non-examination subjects			B. Compulsory non-examination subjects		
1. Civics/current affairs	2		1. Civics/current affairs	2	
2. Physical education	2		2. Physical education	2	
3. Assembly talks	1		3. Assembly talks	1	
4. Music appreciation/singing	1		4. Music appreciation/singing	1	
C. Elective examination subjects (choose 1 or 2)	9	Special approval required for 3 electives	C. Elective examination subjects (choose 1 or 2)	9	Special approval required for 3 electives. Not more than 2 science subjects (including A 4) for any student
1. Additional mathematics		C 2 may not be taken with C 3	1. Additional mathematics		
2. Biology			2. Biology		
3. Human and social biology			3. Human and social biology		C 2 may not be taken with C 3.
4. Woodwork		One of C 4, C 5 and C 6 must be taken	4. Physical science		
5. Metalwork			5. General science		C 4 may not be taken with C 5.
6. Basic electricity and electronics			6. Literature		
7. Literature or history or geography			7. Geography		
			8. History		
			9. Art and crafts		
			10. Needlework and dressmaking		
			11. Cookery		
			12. General housecraft		
			13. Commercial studies		C 13 may not be taken with C 14
			14. Commerce		
			15. Principles of accounts		
			16. Music		
			17. Bible knowledge		C 17 may not be taken with C 18.
			18. Islamic religious knowledge		
	Total 41			Total 41	

3. Services area

school canteen,
bookshop
sick bay, and
car-park

Secondary school time-table

The school time-table represents a spatial reflection of the organizational philosophy of the school. It provides the mechanism by which the various resources (teachers, educational space, equipment and subject) are deployed. Most Singapore schools operate on a double-shift system set within a conventional time-table model of 0730-1300 hours (morning) and 1310-1840 hours (afternoon) session. With some slight variations, a typical 8-period time-table arrangement is as shown in Table 5 below:

Table 5. Typical time-table arrangement

(Morning session)

0730	0810	0850	0930	1000	1030	1110	1150	1225	1300
1	2	3	4	Recess	5	6	7	8	
1310	1350	1430	1510	1550	1610	1650	1720	1800	1840

(Afternoon session)

The usual class pattern of a secondary school is for the upper secondary classes (third and fourth years) to function in the morning and the lower secondary classes in the afternoon session.

Space relationship. In working out the space relationship of instructional and learning areas and administrative and service areas, the questions to consider are as follows:

1. What learning activity should or should not be located next to or in close proximity to other learning activities?
2. What space relationships should exist to facilitate students' and teachers' movement within the school?
3. What space relationship would bring about an optimal use of space?

Of prime concern to the users of the school building is the isolation or separation of noise-generating from quiet learning areas, so that the teaching/learning process can take place in a congenial environment, free from the adverse effect of noise pollution. The acceptance of the need for such separation requires that the technical workshops and school canteen be positioned away from the classrooms, science laboratories and home economics rooms.

To facilitate movement of students and teachers, classrooms ought to be clustered together in the same block with the administration space. Without doubt, the administration and management of the school would best be monitored if the principal's office, general office, staff room, sick bay and bookshop are sited on the ground floor. The science laboratories and home economics rooms could be housed in a separate block.

Space analysis and requirements

A detailed study of the requirements of a school, followed by a space analysis, is a prerequisite to effecting economy in space utilization as reflected in the cost per place for building. The two elements - space utilization and cost per place - are closely related, in that a more intensive and optimal use of learning space would greatly reduce the latter. In Singapore, where the school building functions on a double-shift and sometimes triple-shift system, the cost per place is inevitably lower than if the schools were used for a single shift only.

Space analysis involves the study of two related variables, namely,

1. The size of the individual units for teaching/learning, and
2. The number of these units.

Standards of accommodation for the various instructional areas in a school have to be established with due consideration of the teaching methodology adopted, the type of furniture and equipment used, the area of storage required and the body sizes of the students. The traditional versus progressive - or formal versus informal - methods of teaching have different space requirements. A teacher-centric style in a traditional approach using the chalk-and-talk method would require very much less space than the progressive student-centred approach involving small-group activities and substantial student participation.

In the past the space norms for accommodation were derived from Western standards, usually from the United States of America or Western Europe since, until recently, local architects received their professional education in these countries. These Western standards were, of course, based on anthropometric data of Western children which deviate significantly from those of Asian children. Studies of comparative anthropometric data of Asian children have shown that Western children are much taller than certain Asian children. Table 6 juxtaposes a comparison of consolidated standing heights for children of primary school age in India, Indonesia, the Philippines, Thailand, the United States of America and Singapore.

Table 6. Mean consolidated standing heights for Asian and North American children

Country / Age (in years)	Mean consolidated standing heights in cm					
	Philippines	Thailand	Indonesia	India	United States	Singapore*
7	115	114	110	112	123	121
8	116	119	113	117	130	126
9	122	123	118	122	135	132
10	125	128	122	127	141	137
11	134	133	127	132	147	146
12	138	138	131	137	151	151
13	142	144	136	142	157	156
14	148	149	140	147	163	159

* Ministry of Education, Anthropometric Data, (Singapore : 1977).

The most economic dimensions of spaces for education can be worked out using the following data :

1. Number of children per class;
2. Size of desk and chair based on anthropometric data of students;
3. Circulation space between desks; and
4. Storage space required.

Teaching space

The number of classrooms, science laboratories, home economics rooms, technical workshops and programme spaces can be computed if the following information is available :

1. School enrolment;
2. Class size;
3. Curriculum; and
4. Class structure or number of classes in each grade.

A simple method of estimating space requirements is as follows:

a) Compute the number of space periods (N) for which a particular space can be utilized. For example, if there are r periods a week for which a technical workshop is available, and if p is the percentage of utilization, then the number of space periods available is rp. If r = 50 and p = 80%, then N = rp = 40 space periods.

b) Compute the total space needs of the subject in terms of the number of space periods (n) required. The value of (n) can be calculated from the following formula :

n = no. of subject periods per week(s) X no. of classes (y)

If a technical subject provides for 4 periods a week, and if there are 40 classes using the workshop, then space needs for the workshops are n = 4 x 40 = 160 space periods.

If, as shown in (a) above, a single workshop provides 40 space periods, four workshops would be needed to provide 160 space periods of utilization.

Furniture and equipment

The evolution in teaching/learning methods and the rapid development of new educational technologies increase the importance of providing a greater variety of instructional equipment and furniture to facilitate the learning process. The interdependence of the kind of furniture and equipment needed and the design of the built accommodation has to be given due consideration at the planning state. "Yet, too often the building is conceived and detailed with little certainty of how it will be furnished and equipped, while responsibility for the choice of furniture and major equipment may rest with a purchasing service

which has little knowledge of modern educational requirements." [2] The importance of teachers' participation in the furnishing and equipping of a new school building is therefore critical. The written specifications for equipment and furniture do not have to be complex to enable the architect to grasp the possibilities and limitations of the requirements, but guidelines for furniture and equipment selection are necessary.

2. Lenssen, Paul. *ff5 - A Canadian 'casework' or furniture and equipment system for schools.* Paris, OECD, 1976. p.3 (OECD Programme on Educational Building 4)

Chapter Three

DESIGN OF A STANDARD SECONDARY SCHOOL

Adaptability, flexibility and functionality

The school building is the largest single item of instructional equipment. It strongly influences and shapes teaching styles and methodology in the learning process. Its three most important qualities have been identified as adaptability, flexibility and functionality.

In an era characterized by rapid structural and curricular changes in the education system, it is important that school buildings be designed to give due consideration to these three qualities so as to avoid costly obsolescence. Adaptability and flexibility in school buildings have been succinctly defined as follows:

> "Adaptability has been defined as the quality of a building which enables subsequent alteration to be made to its physical fabric . . . Flexibility is the quality of a building which permits variation in activities without the need for adaptation. [1]

Of all the three qualities of a school building, the functionality element can be considered as the most critical, a functional school building being one in which the teaching/learning process is best provided for in the educational spaces. The designing of adaptable, flexible and functional school buildings is therefore a great architectural and educational challenge.

Components of the school plant

A school plant comprises three main components. These are:

1. School building;
2. Play area/physical education space; and
3. Site circulation paths, car-park, and access road.

An analysis of the area of each of these three components of a standard secondary school in Singapore is given in Table 7.

Space elements

Figure 5 shows the site plan of a standard secondary school in Singapore. Six components can be identified, namely:

1. Workshop block,
2. Assembly hall and canteen block,

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1. Organization for Economic Co-operation and Development. *Providing for future change: adaptability and flexibility in school building.* Paris, OECD, 1976. p.5 (OECD Programme on Educational Building)

3. Science block;
4. Classroom block;
5. Parade ground; and
6. School playing field.

Table 7. Analysis of components of a standard secondary school

Components	Area (in ha)
School building	1.113
Play area/physical education space	1.125
Circulation space, car-park and access roads	0.798
Total	3.036

The space relationship between these six components is apparent. The workshop block is isolated from the science and classroom block to minimize noise interference generated from the machines and workshops. A courtyard provides an effective sound buffer for the classroom block.

Except for the parade ground and the school playing field, the other four components are linked to one another. The workshop block is connected by covered ways to the classroom block and the assembly hall and canteen. The science block and classroom block are also linked by covered ways. Such connections and linkages are important because the secondary school curriculum and scheduling require students to move from one instructional area to another for practical lessons on technical, science and home economics subjects conducted in workshops, science laboratories and home economics rooms respectively. A better understanding of the various teaching spaces can be obtained from Figures 9-12 which show the layout plan of each floor. Details of the teaching space in the workshop block are described in detail in Educational Building Report No. 11, The design of workshops for secondary schools: a case study, Singapore.

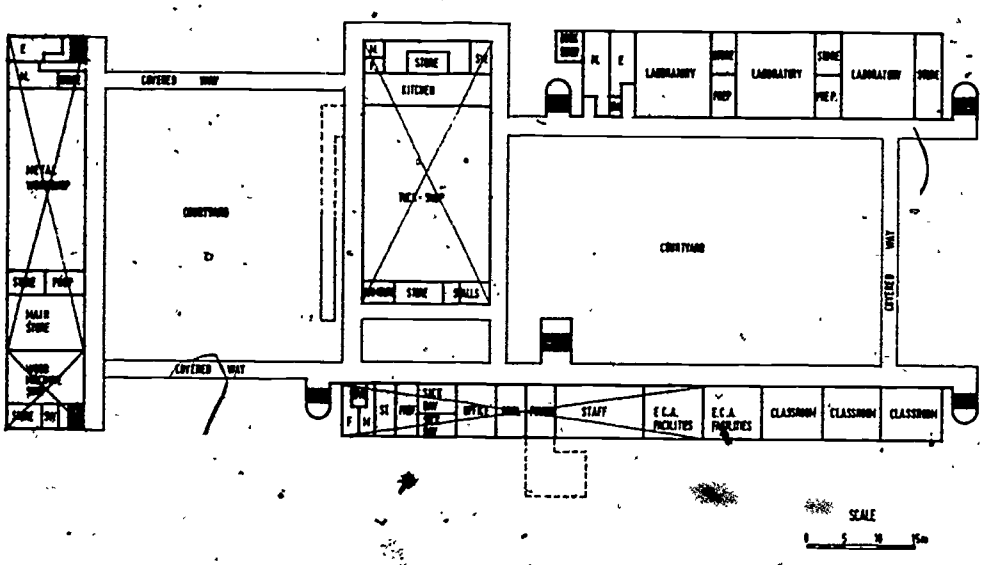

Figure 9. Typical ground-floor plan of a secondary school

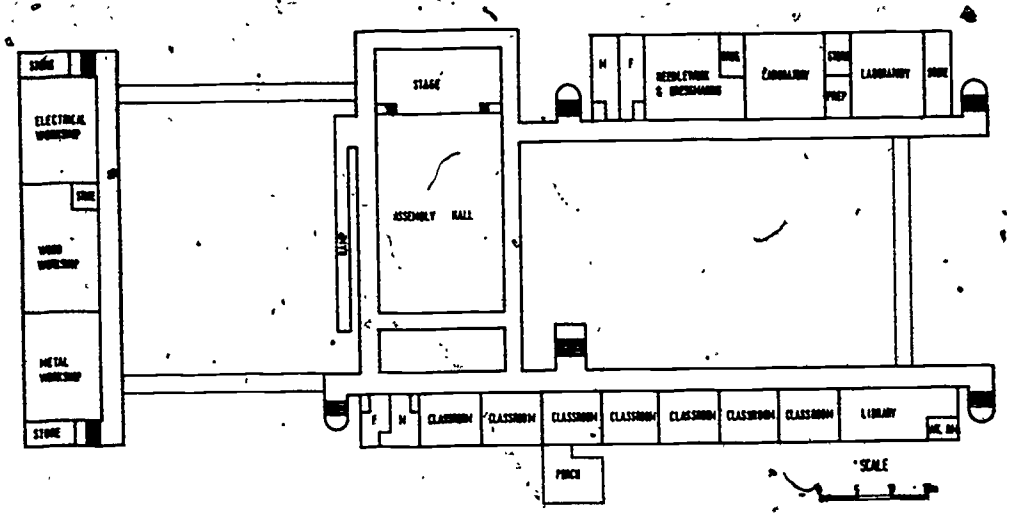

Figure 10. Typical first-floor plan of a secondary school

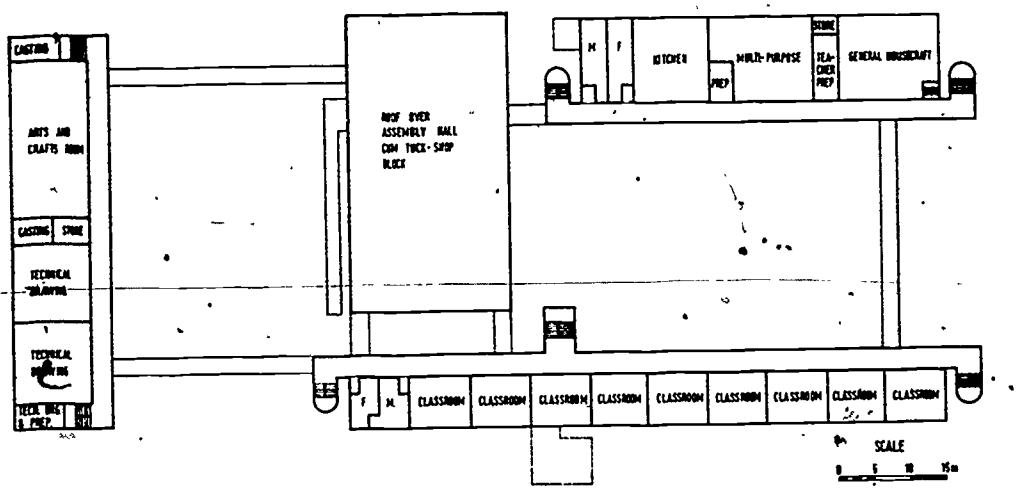

Figure 11. Typical second-floor plan of a secondary school

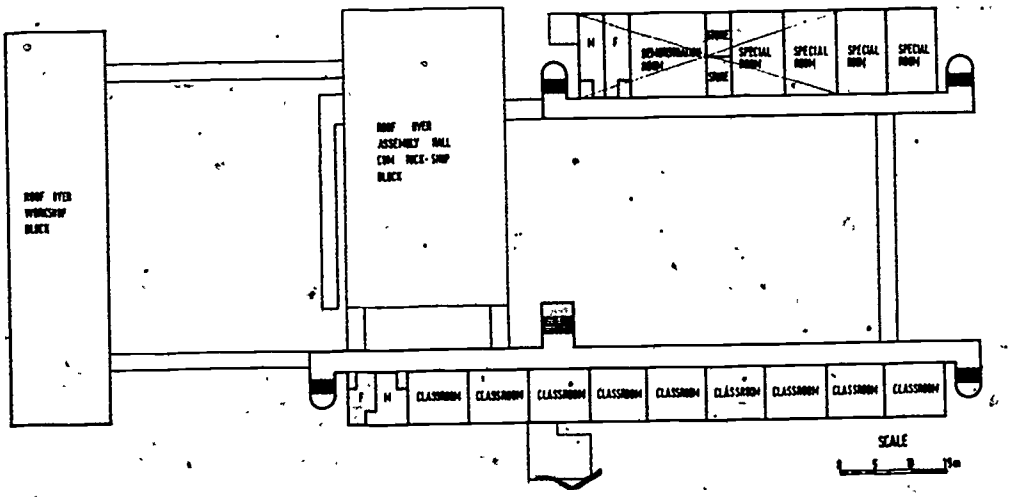

Figure 12. Typical third-floor plan of a secondary school

The classroom block (Plate 1), a three-storey building, accommodates (a) classrooms; (b) administrative space; and (c) service space.

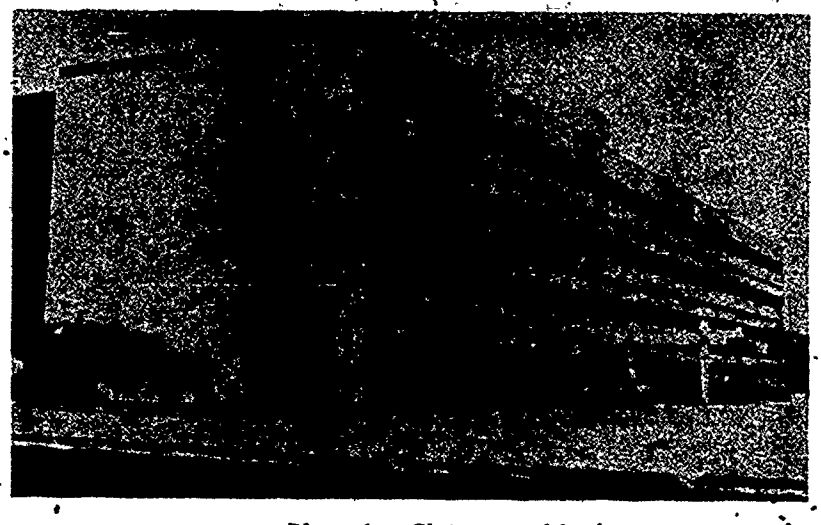

Plate 1. Classroom block

A total of 28 classrooms are provided for in the block: three on the ground floor, seven on the first floor and nine each on the second and third floors. The administrative spaces, comprising the principal's office, general office, staff room, and prefects' room are positioned adjacent to one another on the ground floor. The service space includes two extra-curricular activities rooms, a central library, two sick bays (one for each of the sexes, as the school is co-educational) and toilet facilities on each floor.

The science block (Plate 2), a four-storey building, houses three types of space: (a) five science laboratories; (b) four home economics rooms; and (c) four special rooms and a demonstration room.

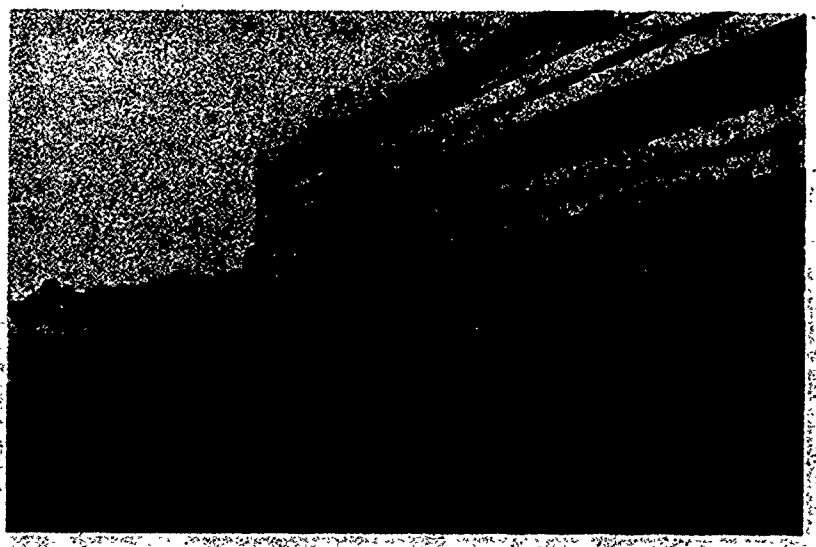

Plate 2. Science Block

A two-storey structure (Figure 13) provides space for the school canteen (known as the 'tuck-shop') on the ground floor and the school hall on the first floor, which doubles its use by providing space for three badminton indoor courts and gymnastic activities.

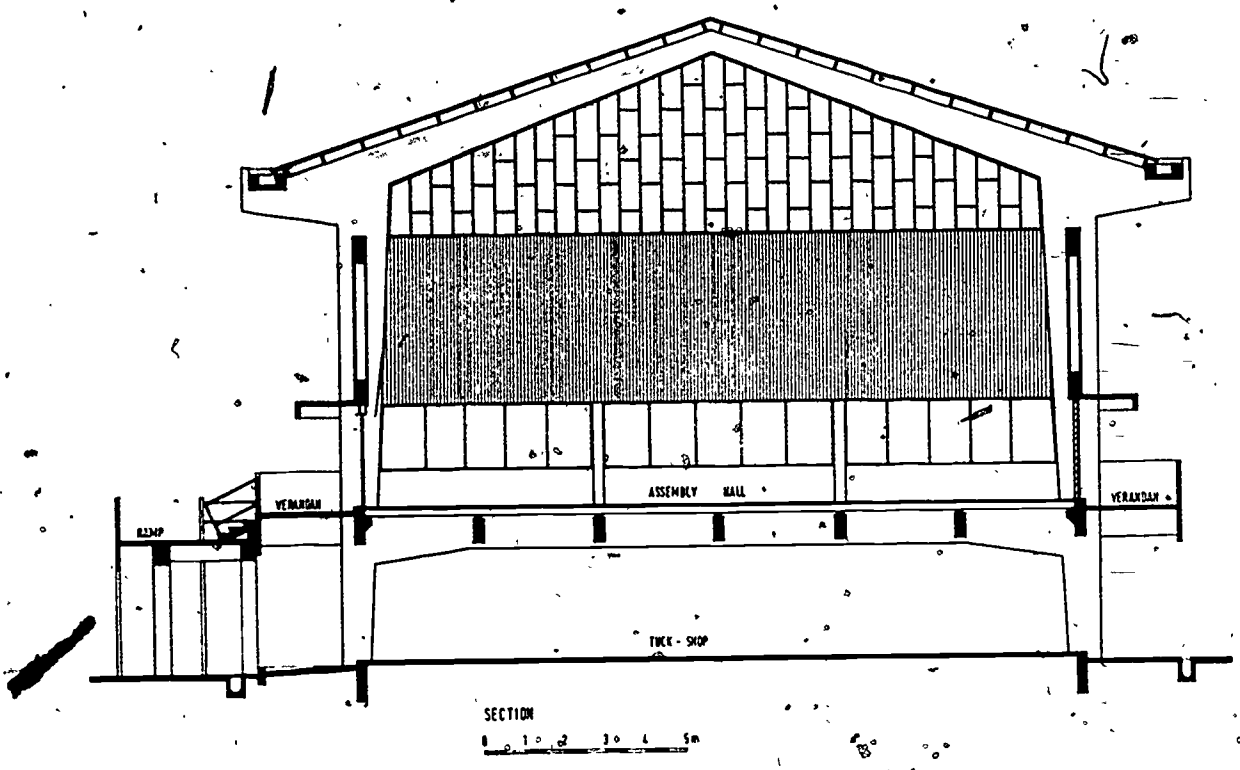

Figure 13. View of assembly hall/canteen showing portal frame

The school playing field incorporates a six-lane, 300-metre running track and a multi-purpose court which can be used for basketball, volleyball and the local ball game known as sepak takraw. A wide range of games, including soccer, hockey, rugger and softball are included in the school physical education programme. The parade ground is used by uniformed organizations of the school including the cadet corps, police corps, Scouts and Red Cross group.

A detailed list of spaces provided is given in Table 8.

Table 8. Space provision approved for secondary schools having 1,120 student places

Space	No. of units	Unit area (sq m)	Total useable area (sq m)
Teaching facilities			
Classrooms	28	64	1,792
Special Rooms	4	88	352
Science Laboratories	5	132	660
Science Stores and Preparation Rooms	8	22	176
Needlework and Dressing Room	1	132	132
Laundry	1	19	19
Store	1	15	15
Fitting Room	1	10	10
Housecraft Room	1	132	132
Store/Preparation Rooms	2	22+13	35
Bathroom	1	9	9
Kitchen	1	132	132
Store/Preparation Rooms	2	22	44
Multi-Purpose Room	1	132	132
Art and Craft Room	2	132	264
Casting Rooms	2	22	44
Stores	1	27	27
(Sub-Total)	-	-	(3,975)
Ancillary Facilities			
Library	1	130	130
Audio Visual Aids Demonstration Room	1	132	132
Extra-Curricular Activities Room	2	64	128
Armoury	1	30	30
(Sub-Total)	-	-	(420)
Administrative Facilities			
Principal's Office	1	27	27
General Office	1	40	40
Staff Common Room	1	95	95
(Sub-Total)	-	-	(162)
Other Facilities			
Bookshops	1	27	27
Prefects' Room	1	25	25
Hall/Canteen	1	1,338	1,338
Stores		As required	
Toilets		As required	
Dustbin Bay		As required	
Rifle Range	1	Standard	
Basketball/Volleyball Court	1	Standard	
Watchmen's Quarters	1	40	40
Sick Bay	1	30	30
(Sub-Total)	-	-	(1,460)
Workshop Facilities			
Metal Workshop I	1	312	312
Metal Workshop II	1	178	178
Wood Workshop (including polishing room of 34 m^2)	1	223	223
Wood Machine shop	1	150	150

Table 8. Space provision approved for secondary schools having 1,120 student places (cont'd)

Space	No. of units	Unit area (sq m)	Total useable area (sq m)
Electrical Workshop	1	178	178
Technical Drawing Room	2	134	268
Technical Drawing Preparation Room	1	26	26
Stores, Miscellaneous Materials Stores (Timber Store of 34 m^2 to be built separately)	1	56	56
Tools Store	1	20	20
Category V, Sub-Total			(1,411)
Grand Total			7,428
Circulation, walls etc.			1,772
Total gross floor area			9,200
Gross floor area per student place			8.21

The norms for sites are 3.03 ha per school including 4.8 sq.m. per student place for playgrounds and sports areas. Typically, the buildings occupy about 1.11 ha, play and sports areas take up 1.13 ha. and the remainder is utilized for access roads, car park and circulation.

Orientation of school buildings

To provide optimum sun-shading for a building in Singapore, the best orientation is with the longitudinal axis in the east-west direction. Windows are best located facing north or south where they are not subjected to low-angle early morning or late afternoon sunlight. This is an ideal orientation but one which may be difficult to obtain where the land is of limited size and irregular configuration. Alternatively, buildings are oriented with the windows facing east or west, in which case specially designed sun-shading devices are provided. If natural ventilation from prevailing breezes proves inadequate ceiling fans are provided.

Distinctive features

The standard secondary school patterned on the 1974 PWD model was the result of close collaboration and co-ordination between educators of the Ministry of Education and PWD architects. It represents the architectural translation of the Ministry of Education educational specification.

The arrangement of the school is very simple as shown in Figure 5. The internal courtyard is enclosed by the classroom block, science block and hall and tuckshop block. This courtyard is turfed and serves as a relaxation venue for students during recess time. For acoustical reasons, the workshop block is isolated from these blocks, but linked by corridors to provide covered access.

The distinctive feature of the design lies in its flexibility. Each block is designed to be independent and has its own staircases and toilet amenities. This flexibility of arrangement permits the standard school to be accommodated on sites of varying dimensions. Figures 7 and 8 illustrate an alternative arrangement of the school to fit an irregular site.

As can be seen from the layout plan of the standard secondary school, the assembly hall-with-canteen block and the workshop block are not orientated in a north-south direction but in an east-west direction for several reasons. Mainly the positioning of these two blocks is determined more by the functional and circulation requirements in relation to the classroom block and the science block than by solar considerations. The functional requirements necessitate their close proximity to the classroom block.

The materials used in the 1974 PWD design for standard secondary schools are durable in nature and create few maintenance problems. Roofing materials consist of interlocking, configured sheet metal which, because of its special profile, can be used for very low-pitched roofs without leakage problems. In addition, its light weight is advantageous structurally and economically. External walls are brickwork and are left either fairfaced, or plastered and painted. This allows a greater variety in texture and colour, yet affords easy maintenance. Where large areas of cladding are required, as for the assembly hall, heavy-duty colour-impregnated asbestos sheet, a tough maintenance-free sheeting material, is used.

All windows used in the school are glass-louvred because they are cheaper and provide better ventilation during heavy rain. Doors, and frames for doors and windows, are of durable tropical hardwood. Generally, woodwork is painted with three coats of enamel paint because it has been proved that this method of protection withstands the weathering of the tropics and strong, ultra-violet rays of the sun. The timber floor in the assembly hall is a tropical hardwood which is termite-resistant. Flooring for most other areas is of cement rendering which has proved satisfactory and economical through the years.

Toilet finishes consist of mosaic flooring and glazed wall tiles up to door-height. Waste pipes used are of cast iron except in the science laboratories where plastic waste pipes are used. These are chemically resistant, and lead the waste to traps and special diluting tanks before discharging to manholes. All gutters and rain water pipes are of polyvinyl chloride (PVC) to prevent corrosion.

School sites are landscaped after building works have been completed. The courtyards and school fields are turfed, school fences are planted with hedges and the school grounds and car parks are planted with trees. Landscaping of the courtyard is often done by the students of the school which results in individual and strikingly landscaped areas. This is in keeping with the Government's policy of making Singapore a garden city and of encouraging students to use their hands.

Classrooms

The shape and size of classrooms are dependent on a number of factors, including teaching methods, seating pattern and its effect on audibility, the angle of vision with the chalkboard and the size of furniture. In Singapore, there is very little experimentation with shapes of classrooms. The rectangular classroom with permanent walls on all four sides is the accepted pattern, although lately, in an attempt to inject innovation in school architecture, hexagonal-shaped classrooms were experimented with in one of the winning

entries of the School Building Design Competition. As teaching methods of the conventional or traditional style (i.e. the teacher-centric approach) are prevalent in Singapore schools, and as the progressive or non-formal styles of teaching have yet to prove their superiority, the design of classrooms closely follows the traditional model.

The subject areas for which classrooms are used as follows:

1. Language arts;
2. Mathematics; and
3. Social studies (including history, geography, civics).

Teaching aids used in classrooms include chalkboards, overhead projectors, maps, charts and the like. The design of the classroom has to provide the appropriate facilities for these aids, including adequate storage space.

The educational specification of a standard secondary school sets out a space norm for 40-place classrooms of 64 m^2, that is, an area per place of 1.6 m^2. Plate 3 illustrates a typical classroom layout based on the furniture design shown in Plate 4. A salient feature of the classroom is the provision of built-in cupboards as space for storing books and equipment. Another interesting

Plate 3. A typical classroom

Plate 4. Classroom desk and chair

feature concerns the separation of three classrooms on the first floor with sliding and folding partitions (Plate 5). The purpose of this is to attain flexibility in the utilization of teaching spaces.

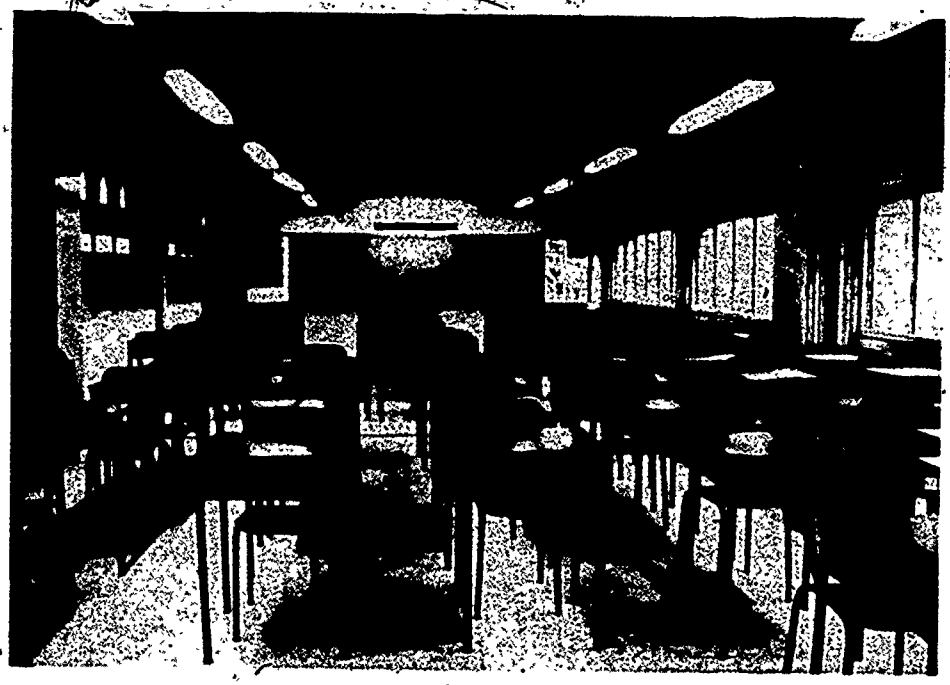

Plate 5. Double classroom with folding partition

Special classrooms

In Singapore, special classrooms are allocated for teaching a wide variety of subjects and are also used to cater to the special interests of the school. These include special rooms for history and geography, mathematics, music, hobbies and clubs. In recognition of the special uses to which these rooms are put, they are larger than the normal classroom. A floor space of 89 m^2 is the space norm for special rooms. The rooms are furnished like normal classrooms with the addition of special items of equipment such as globes and maps in a geography room.

Science laboratories

School science education in Singapore is considered to be of focal importance in view of the dependence of industry on scientific and technological manpower. This importance is reflected in the school curriculum which provides for the teaching of science at both the primary and secondary levels. In secondary schools, general science, comprising biology, physics and chemistry, is taught in grades VII and VIII, using a practice-oriented approach. Most science lessons are conducted in the science laboratories. In grades IX and X, pure science subjects (physical science and biology) are offered.

Based on a 70-per-cent utilization of science laboratory space, a total of five science laboratories are needed for a standard school. The design of the

science laboratories is shown in Figure 14. Basically, laboratory design is patterned on the traditional model with long, fixed benches equipped with fixed ceramic sinks, fixed water supply outlets and gas and electrical points. Storage spaces for science equipment and apparatus are provided in the specially-designed benches and also in built-in cupboards lining the sides of the laboratories (Plates 6, 7 and 8).

As science laboratories are provided with special equipment often requiring the installation of services including gas and electricity, planning of the location of science laboratories has to be considered very carefully. Generally, it is preferable to locate a chemistry laboratory on the ground floor to reduce the length of the plumbing system, thus reducing the risk of blockages.

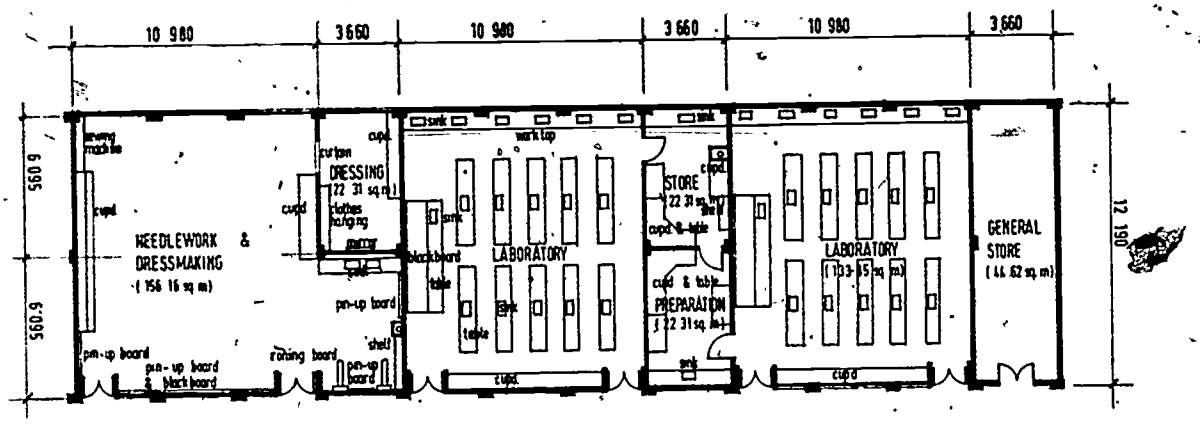

Figure 14. Layout plan of science laboratories (Science block 1st floor)

Plate 6. Science laboratory

Plate 7. Bench storage space

Plate 8. Side storage space

Preparation- and store-rooms are needed and are attached to the science laboratories, sandwiched between the two science laboratories to provide dual entry and use (Plate 9). Accessibility between the laboratories and preparation rooms is direct.

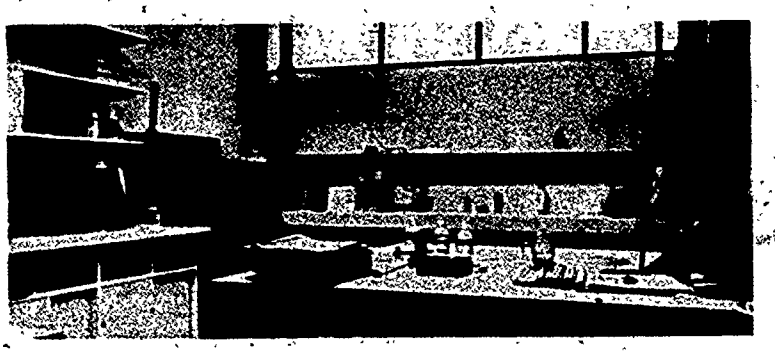

Plate 9. Science preparation room

Home economics rooms

The home economics course offered at the second level of education in Singapore is directly related to the students and their everyday lives, as it gives them a better understanding of the subject matter pertaining to education for home and family living, food and nutrition, fabrics and fashion, consumer education and money management. Subjects taught in home economics include needlework and dress-making, cookery and general housecraft.

Four types of education spaces are provided for the teaching a home economics, namely:

1. Needlework and dressmaking room;
2. Kitchen;
3. Multi-purpose room; and
4. General housecraft room.

Figures 14 and 15 give a line drawing of the layout plan of the four home economics rooms. The detailed layout, furniture and facilities in these rooms are shown in Plates 10, 11 and 12.

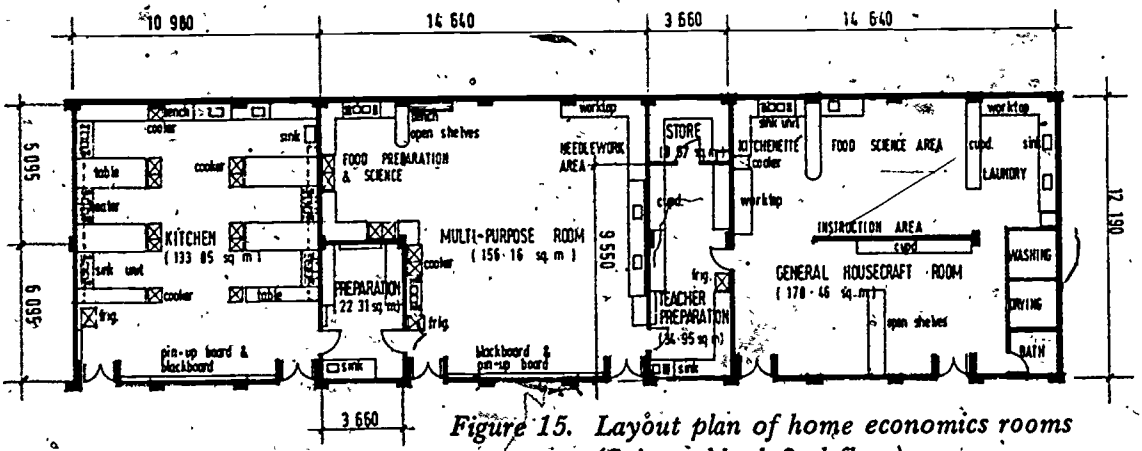

Figure 15. Layout plan of home economics rooms (Science block 2nd floor)

Plate 10. Needlework and dressmaking room

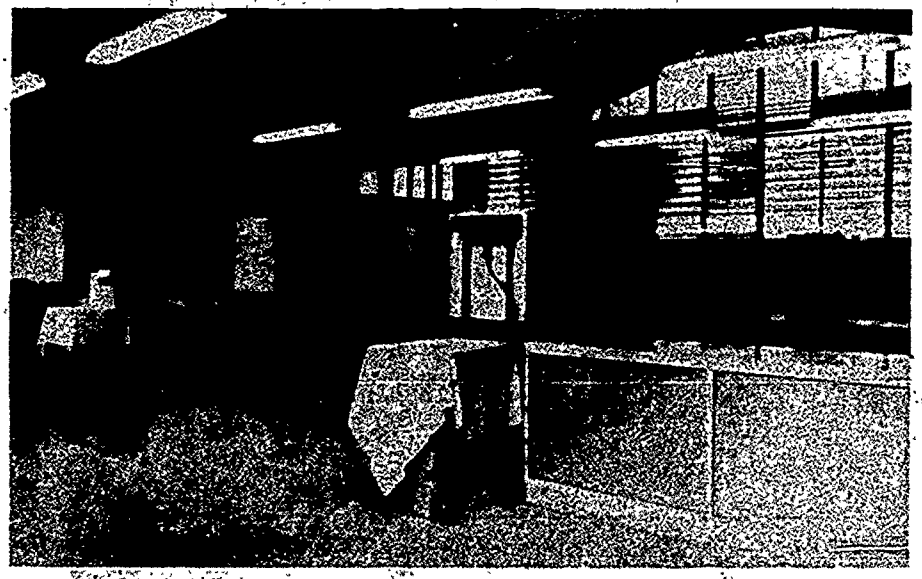

Plate 11. Kitchen

Plate 12. General housecraft room

Hall and canteen

A two-storey building houses the canteen on the ground floor and the hall on the first floor. The hall serves a number of purposes. It is used for weekly assemblies and other school functions such as school concerts, plays and other special events. The hall is also used for badminton and includes provision for three standard courts. Gymnastics and table tennis are also catered for in the school hall. Line drawings of the layout plan of the hall and canteen are given in Figures 16 and 17.

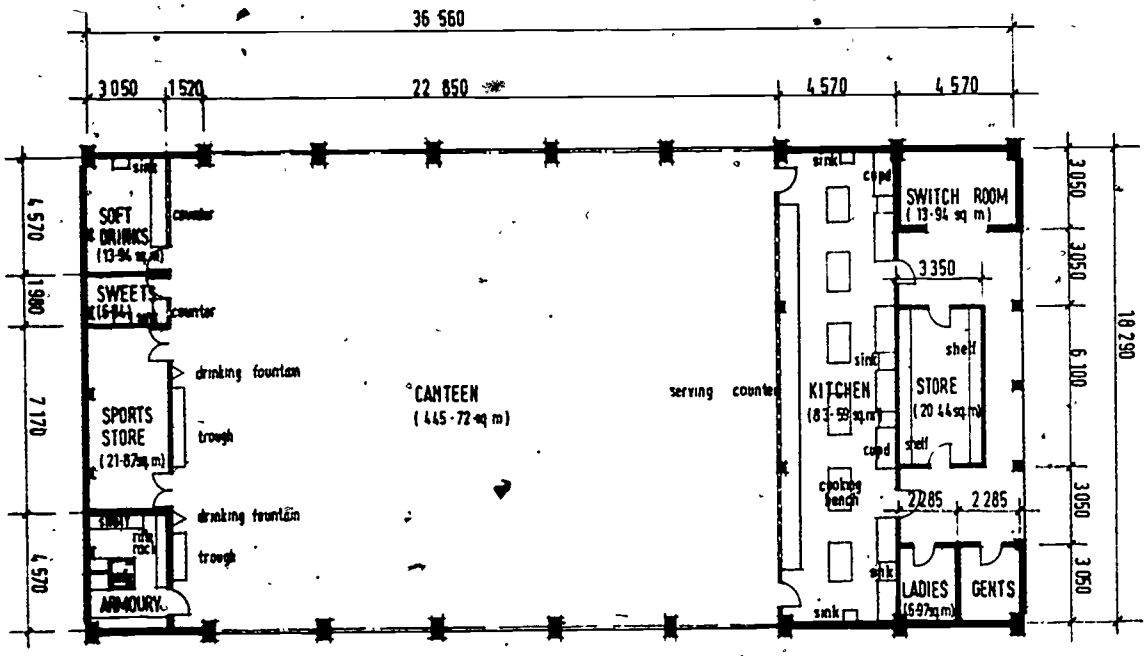

Figure 16. Layout plan of canteen (Assembly hall, ground floor)

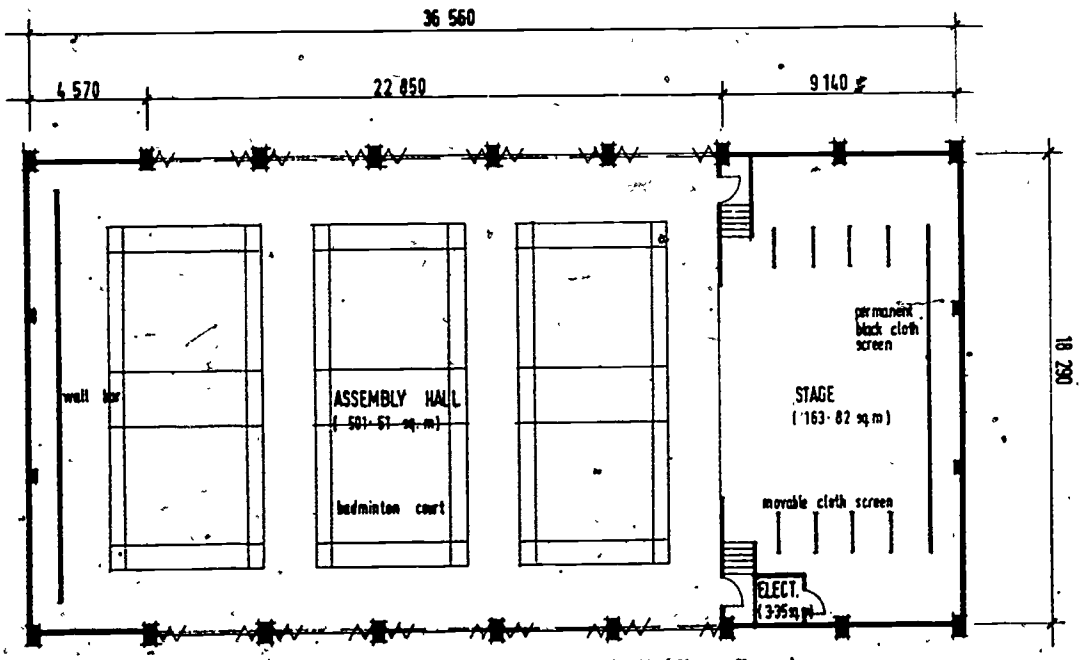

Figure 17. Plan of assembly hall (first floor)

Arts-and-crafts rooms

Two specially-designed rooms are provided for the teaching of arts and crafts. The latter includes the teaching of ceramics, wood sculpture, print-making, puppetry, fabric design, weaving and metal relief. Two casting rooms and an arts and crafts store are attached to the two rooms. The design of the rooms is shown in Figure 18.

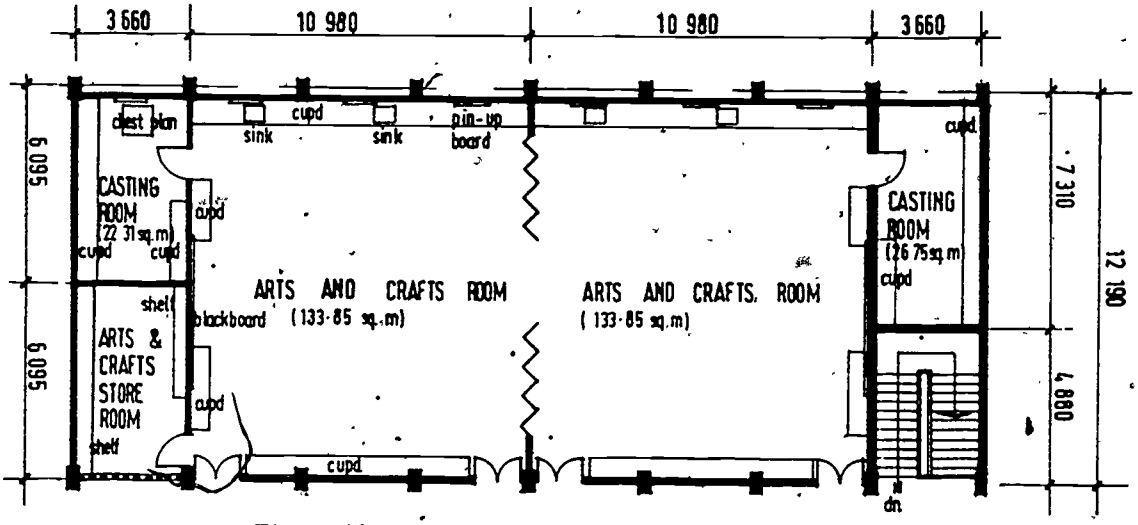

Figure 18. Layout plan of art and crafts rooms (Workshop block, 2nd floor)

Resource centre

The resource centre in the secondary school comprises two main components: the school library and the audio-visual aids room. The latter can accommodate two classes of 80 students and is used whenever audio-visual aids are needed in the lessons.

The minimum recommended standard aimed at in the provision of books in school libraries is five titles per secondary school student and two titles per primary school pupil with two or three copies per title for all new schools. Most schools have adequate funds to meet the standards, which also recommend a list of basic audio-visual equipment.

Workshops

The vocational aspects of education provided in the curriculum are developed in the technical drawing rooms and the workshops. As we have already seen, every school includes a separate workshop block with shops for woodwork, metalwork and electricity and electronics. These workshops are more fully described by the authors in Educational Building Report 11. [2]

2. Michael Liew Kok-Pun et al, *Workshops in secondary schools, Singapore*, Bangkok, Unesco, Regional Office for Education in Asia and Oceania, 1979, 34 p.

Chapter Four

COST ANALYSIS

Introduction

The cost of a school building is influenced by a number of factors. These include:

1. The enrolment, and the intensity of utilization of educational space;
2. The total area of built space;
3. The location and physical nature of the sites, i.e. the need for piling;
4. Market prices of labour and building materials; and
5. Building regulations such as those controlling ceiling heights, use of materials, or 'disaster-proof' construction.

Preliminary estimate

The preliminary estimate of the cost of a school building in Singapore is undertaken by the quantity surveying section of the PWD and is based on the sketch plans prepared by the architectural section. The primary function of the preliminary estimate is to produce a forecast of the probable cost of the project before the building is designed in detail and contract particulars prepared. In this way the Ministry of Education is made aware of the likely financial commitments before extensive design work is undertaken. The preliminary estimate is not a prediction of value but a prediction of cost. The likelihood of price fluctuations (increases) between the estimate and tender date must be taken into consideration, and a percentage factor for unforeseen costs added.

Project details

The design concept, space analysis and a description of the materials used in the construction of the school buildings have been included in Chapter Three. In addition to the buildings, the project includes the external works such as fencing, access roads and car-park, planting of trees, the establishment of the garden, a multi-purpose hard court for basketball, volley ball or other sports, a rifle range and a garbage collection area.

The average total cost of a standard secondary school, at 1980 prices, is S$8.68 million (US$4.05 million) giving an overall project cost of S$934 per m^2 (US$441 per m^2) and a per place cost, based on an enrolment of 2,240 students, in two shifts of S$3,873 (US$1,810).

An analysis of the project costs is given in Table 9 and it may be of general interest to note the high percentage of the total cost allocated for the science and workshop blocks.

Table 9. Analysis of project costs

Description	Cost in (S $)	% of total cost	Gross floor area (m^2)	Cost per sq. m. (S $)
Building				
Classroom block	1,668,000		2,900	575
Science block	1,860,000		2,690	691
Workshop block	1,065,000		1,950	546
Assembly hall-cum-canteen block	980,000		1,340	731
Timber shed	30,000		40	750
Covered ways	150,000		280	536
Total building cost	5,753,000	66.3	9,200	625
Services				
Plumbing				
Electrical installation	340,000			
Gas installation	30,000			
Total services cost	370,000	4.3		
External				
Site Work				
Site clearance, earthworks, turfing and tree-planting	140,000			
Roads and car-park	255,000			
Footpath, steps and ramp	5,000			
Fencing and gates	41,000			
Flagstaff	1,850			
Multi-purpose court	25,000			
Goal posts	2,400			
Dustbin bay	6,800			
Planting of hedges	8,000			
Drainage				
Foul drainage	190,000			
Diluting tank	2,700			
External Services				
External sewerage and connection	10,300			
External water mains and connection	10,300			
External electrical mains and connection	51,000			
External water supply	19,900			
Ancillary Building				
Rifle range	72,000			
Total cost of external works	841,250	9.7		
Ancillary Costs				
Site investigation	15,000			
Preliminaries	400,000			
Insurances	45,000			
Site telephone	1,500			
Salaries/supervision	50,000			
Contingencies	400,000			
Total ancillary costs	911,500	10.5		
Piling costs	800,000	9.2		
Total all costs	8,675,750	100.0	9,200	934