DOCUMENT RESUME

ED 132 653 EA 008 932

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TITLE The Design of Multi-Purpose Science Laboratories for Lower Second Level Schools in Asia. Study No. 11.
INSTITUTION Asian Regional Inst. for School Building Research, Colombo (Sri Lanka).
SPONS AGENCY United Nations Educational, Scientific, and Cultural Organization, Paris (France).
PUB DATE 70
NOTE 63p.; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS Design Needs; Equipment Storage; Facility Case Studies; *Facility Guidelines; Facility Requirements; Flexible Facilities; *General Science; Human Engineering; Multipurpose Classrooms; *School Planning; *Science Laboratories; Secondary Education; Space Utilization
IDENTIFIERS *Asia

ABSTRACT

The small size of many schools in the Asian Region would cause separate laboratories for chemistry and biology to be underutilized. In many larger schools the curricula include "general science," with contents from biology, physics, and chemistry. This paper describes multipurpose spaces for science activities sufficient for science teaching and learning in all three fields. The study deals with the analytical phase of the design problem, relates the initial analysis to the specific laboratory design problem, and applies it to two design situations. A multiscience laboratory design for Ceylon includes a storage unit, but no fixed services are needed or provided. The transport of equipment between the storage unit and the work stations is facilitated by the use of mobile service units that can be attached to the work tables in different positions. An integrated science laboratory design for Malaysia provides fixed services installed in fixed units, but with movable oak tables. (Author/MLF)

STUDY 11

THE DESIGN OF MULTI-PURPOSE SCIENCE LABORATORIES FOR LOWER SECOND LEVEL SCHOOLS IN ASIA

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ASIAN REGIONAL INSTITUTE FOR SCHOOL BUILDING RESEARCH

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ASIAN REGIONAL INSTITUTE FOR SCHOOL BUILDING RESEARCH

STUDY No.11

THE DESIGN OF MULTI-PURPOSE SCIENCE LABORATORIES
FOR
LOWER SECOND-LEVEL SCHOOLS IN ASIA

by

B. H. Söderberg
ARCHITECT

COLOMBO
1 9 7 0

Plate I   Pupils preparing movable service unit for science lesson.

PREFACE

The size of many schools in the Asian Region, especially in the rural areas, is such that, were separate laboratories for physics, chemistry and biology to be provided, they would be grossly under-utilized. In such cases, one laboratory is usually sufficient for science teaching and learning in all three fields. However, the curricula of many States, especially at the lower second-level of education, include a subject known as General Science, Science or in the case of one country, Integrated Science. These various titles usually indicate the inclusion in the curricula of material from the fields of biology, physics and chemistry, which may be taught either consecutively or as concept areas in which a topic such as heat is dealt with in its physical, biological and chemical contexts.

This pape describes spaces suitable for the multi-purpose of all of the above science activities at the lower second level of education. As is the practice in many of the Institute's papers, it has been felt more useful to discuss the general aspects of the problem and to describe how the principles established are applied to situations in the Region. The two case studies described here relate to the lower second-level science curricula of Ceylon and the Integrated Science curriculum of Malaysia. The Governments of both countries have been sufficiently interested in the ideas expressed to allow the Institute to try them out in full scale laboratories. In Ceylon, a laboratory has already been furnished in a standard building and is currently under study to determine to what extent the criteria for design are valid and in what ways the teachers and children respond to the new environment provided. The Malaysian laboratory, also in a standard school, is presently under construction and will be similarly studied when it is occupied. The Institute is grateful to the respective Governments for their collaboration, the results of which will be reported in a separate paper at the conclusion of the field trials.

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SUMMARY

The size of many schools in the Asian Region, especially in the rural areas, is such that were separate laboratories for chemistry and biology to be provided, they would be grossly under-utilized. In such cases, one laboratory is usually sufficient for science teaching and learning in all three fields.

However, the curricula of many States, especially at lower second-level, include a subject known as General Science or just Science. This subject includes contents from biology, physics and chemistry, which may be taught either consecutively or as concept areas in which a topic such as heat is dealt with in its physical, biological or chemical context. For the purposes of this paper, spaces for this type of learning are called *Intergrated Science Laboratories.*

The design of science teaching spaces for both of the situations outlined above presents many common problems which are best brought out through the media of case studies for particular situations. This indicates a design approach adopted for situations in two countries. A similar approach can be used for other similar situations, although the solution may be different. The cases considered are the design of an Integrated Science laboratory in an area of its own for Malaysia (I), and of a Multi-Science laboratory for Ceylon (II) where it is proposed to use a section of a typical hall-type school for science teaching at lower second-level.

The solution of Case I is for a more sophisticated situation where fixed services will be provided. These have been installed in fixed units located strategically in the laboratory. The work tables are movable.

A solution of Case II includes a storage unit made of prefabricated wooden elements which, placed strategically in the open hall building, serves, besides its storing function, as a room divider and as a chalk-pinup board. The transport of equipment between the storage unit and the work stations is facilitated by the use of mobile service units which can be attached to the work tables in different positions. No fixed services are needed or provided.

The approaches in both Case Studies came about through analysis of needs resulting from a study of teaching method, available equipment and schemes of work.

RÉSUMÉ

En beaucoup de pays d'Asie les programmes d'études - surtout au niveau du premier cycle secondaire - comprennent la matière dénommée "sciences générales" ou simplement sciences. Sont rassemblés sous ce nom des éléments de biologie, de physique et de chimie qui peuvent être enseignés soit séparément, soit dans le cadre de centres d'intérêt - par exemple la chaleur - qui sont explorés simultanément du point de vue physique, biologique et chimique. Les locaux destinés à cette forme d'enseignement sont appelés des "laboratoires intégrés".

Les problèmes que pose la conception de ces laboratoires sont souvent les mêmes pour l'un et l'autre type; le meilleur moyen de les mettre en évidence consiste à étudier des cas concrets. Nous exposons dans cette étude la méthode appliquée dans deux pays. Dans toute autre situation similaire, cette même méthode pourra être utilisée mais la solution sera peut-être différente. Deux cas sont considérés à cet effet; (I) un laboratoire intégré ayant ses propres locaux, dans une école de Malaisie, et (II) un laboratoire polyvalent à Ceylan, où l'on désire utiliser une section du hall de l'école (à Ceylan de nombreuses écoles rurales comprennent une seule salle ou "hall") pour l'enseignement des sciences au niveau du premier cycle secondaire.

La solution proposée pour le cas no. I est un dispositif perfectionné comportant des installations fixes, disposées stratégiquement dans le laboratoire. Les tables sont déplaçables.

La solution proposée pour le second cas comprend a) une unité de rangement, faite d'éléments de bois préfabriqués qui, placés stratégiquement dans la salle type "hall", sert non seulement d'armoire, mais aussi de cloison, de tableau et de panneau d'affichage. Le transport du matériel entre l'élément de rangement et les postes de travail est facilité par l'utilisation d'unités mobiles qui peuvent être fixées aux tables en différents endroits. Comme les installations fixes ne sont pas nécessaires, elles n'ont pas été prévues.

L'approche aux deux études de cas survint par l'analyse des besoins résultant de l'étude des méthodes d'enseignement, de la disponibilité de l'équipement et des schémas de travail.

INTRODUCTION

The Institute has already published studies on the design of lower second-level laboratories for chemistry, physics and biology teaching. This study deals with the design of laboratories for the same level of education but in which all three sciences may be taught in one form or another. Whilst separate laboratories for each field of science teaching and learning are no doubt convenient, the demand, especially in the rural areas of Asia, is for a single, inexpensive space in which the children of smaller schools can have the same opportunities for science learning as other children who are fortunate enough to attend the larger and usually better equipped urban schools.

Few education authorities can affort to build teaching spaces that are not economically used. Utilization of teaching spaces varies, depending on their function. One hundred per cent utilization can be expected of the normal classroom. Workshop and laboratories, on the other hand, are normally not used for more than from 80 to 90% of the week as, between periods, there is a need for cleaning up and preparation for the next lesson. Assuming that the economic use of a laboratory is to be ot more than 80%, it is possible through a study of the curr ula for science teaching in the countries of the Asian Region, to determine the needs for accommodation in relation to enrolment patterns. Obviously, a single stream school, that is, a school with only one class group or section of each grade, will require less accommodation than a two or three stream school with two or three teaching groups or sections per grade.

Table I shows the labor ory needs for different situation . It assumes a maximum u lization of 40 periods per week and an economic utilization of 0% or 32 periods.

TABLE I - LABORATORY NEEDS FOR LOWER SECOND LEVEL SCHOOLS IN THE ASIAN REGION

Country	Grades 1/	Period/Week. Lower Secondary				Total periods per week	N°. of labs. needed 2/		
		Chem.	Bio.	Phys	Int.Sc. Gen.Sc. or Sc.		1 Stream	2 Streams	3 Streams
i	*ii*	*iii*	*iv*	*v*	*vi*	*vii*	*viii*	*ix*	*x*
AFGHANISTAN	VII- IX	6	6	6	-	19	1	2	2
BURMA	VI- IX	-	-	-	19	19	1	2	2
CAMBODIA	VII-VIII	2	4	2	-	8	1	1	1
CEYLON	IX- X	10	12	10	-	32	1	2	3
Republic of CHINA	VII- IX	-	-	-	11	11	1	1	1
INDIA	VIII- X	-	-	-	15	15	1	1	2
INDONESIA	VII- X	3	8	11	-	22	1	2	3
IRAN	VII- IX	4	6	4	-	14	1	1	2
JAPAN	VII- IX	-	-	-	12	12	1	1	2
Republic of KOREA	VII- IX	-	-	-	10	10	1	1	1
LAOS	VII- X	1	-	1	9	11	1	1	1
MALAYSIA	VII- IX	-	-	-	15	15	1	1	2
MONGOLIA	IX- XI	8	2	9	-	19	1	2	2
NEPAL	VI-VIII	-	-	-	12	12	1	1	2
PAKISTAN	VI-VIII	-	-	-	15	15	1	1	2
PHILIPPINES	VII- X	-	-	-	20	20	1	2	2
SINGAPORE	VII-VIII	-	-	-	12	12	1	1	2
THAILAND	VI- IX	4,5	6	4,5	-	15	1	1	2
Republic of VIET-NAM		2	2	2	-	6	1	1	1

Notes: 1/ Number of grades varies with school system

2/ The number of laboratories are calculated on a school week of 40 periods and a use-factor = 80% or 32 periods

Some comment is necessary on columns (vii), (ix) and (x) of Table I. It will be noted that for all countries only one laboratory is required for each single stream school (column viii). In fact the utilization will in most cases, be substantially less than the 80% mentioned above. In The Republic of Korea and Cambodia, the utilization will be only 30%, whilst in eight other countries, it will only be 40%. Afghanistan and Burma would make

60% use of a single laboratory whilst Ceylon would slightly over-utilize at 100%. (In such a case, a small, carefully selected portion of the syllabus could be taught in an ordinary classroom).

For two stream schools, only Afghanistan, Burma, Ceylon, Indonesia, Mongolia and the Philippines need two laboratories whilst, even with two streams, the remaining countries would still be making less than economic use of a single laboratory.

Where there are three streams, Ceylon and Indonesia would require three laboratories and thus could economically provide separate facilities for chemistry, physics and biology teaching. Some countries, however continue to require only one laboratory, and four of the nineteen countries, even with three streams in their schools, need only one teaching space for science.

It is clear from the foregoing, that the old conception, still common in a few countries of the Region, that a separate laboratory is needed for each of the three sciences, is not valid on the basis of economic use of the capital invested in buildings. It may be a valid conception in relation to the teaching needs and it is one of the purposes of this paper to explore this point and to show whether or not a laboratory can be designed to provide for these needs in a single space.

A further and final conclusion that can be drawn from the study of the present position in the Region is that when there is uneconomical use of teaching spaces, there is also likely to be uneconomical use of scarce science teachers. The need for a single laboratory in which to teach all three sciences has also to be matched by a teacher able to perform the function of a multi-science teacher. The situation thus has implications for teacher training as well as for building design.

APPROACH TO THE LABORATORY DESIGN PROBLEM

The study that follows is divided into two parts: The first deals with the analytical phase of the design process and its content is, to some extent, relevant to the analysis of any design problem, although in this case it has, of course, a science laboratory flavour. The second part identifies to what extent organizational factors are likely to influence the design in the case of multi-science and integrated science laboratories. The second part in fact relates the initial analysis to the specific laboratory design problem and applies it to two design situations the one, multi-science laboratory design for Ceylon, the other integrated science laboratory design for Malaysia. In the second part, the general factors established in the analysis are ordered to give them weight in relation to their importance in the two situations under study. Subsequently, the weight factors form the basis of translation into architectural languages.

4.

A. THE STUDENT

1. General

A principal once said, "Don't make the furniture too comfortable because the students might fall asleep". Probably, at some time or other, students had fallen asleep during his lessons and he may have thought the reason for this was the excessively comfortable furniture. Others might think that a laboratory should be designed to be as comfortable as possible in order to provide the maximum convenience in use.

There are two aspects of comfort, the physical and the psychological. It is the author's opinion that a physically comfortable laboratory is a pre-requisite to the establishment of the frame of mind in which the student is ready to learn. Discomfort impedes learning and the impedance increases as the lesson proceeds with increasing difficulty in retaining interest in experiments or in listening to the teacher. What has to be remembered is that, in most situations, the laboratory is being used by an average teacher and by students, many of which are not highly motivated towards science learning. Comfort, in such a case, is likely to be of greater significance than may be thought.

Physical comfort involves the provision of enough light to see the chalkboard, to write and to work easily; it involves ease of movement, ease of sitting etc. The criteria for comfort, will be established in the following sections.

2. The Design Student

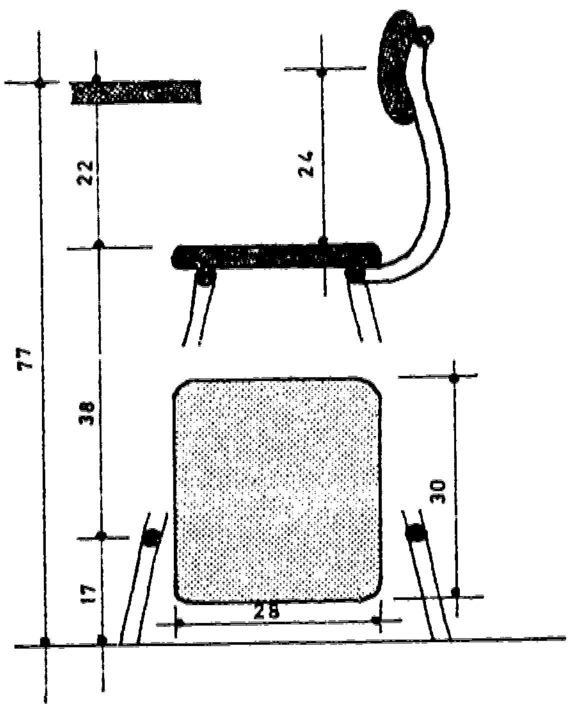
The age range of the students using the laboratories, which form the subject of this study, is from about 13 to 15 years. Their mean standing heights are as follows:-

Age 13 years - 141 cm.
14 years - 146 cm.
15 years - 151 cm.

The 14 year old has been selected as the "design student" for purposes of sizing the furniture, fittings and building details of the laboratories.

3. The Student and the Laboratory Bench

The most critical aspect of laboratory design is the height of the working surface above floor level. This is somewhat difficult to define as, for part of the time the student will be sitting to work and, for the rest of the time, standing.



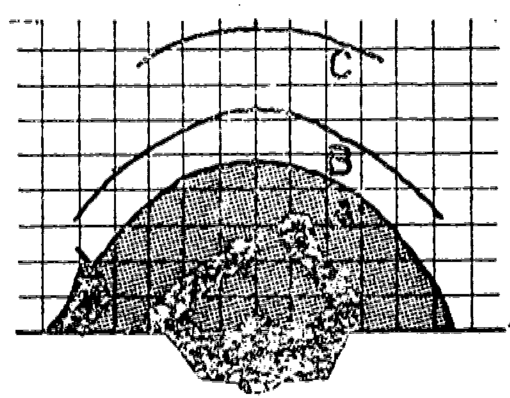
IMPORTANT MEASUREMENTS FOR CONVENIENT SITTING
fig. 1

The most convenient height for standing work, in respect of the 14 year old "design student" is 61cm. The design solution (to this problem) is to provide a chair or stool, the height of which makes sitting at the 76cm high bench most comfortable. A stool to meet this need will have its seat at 55cm above floor level and will be provided with a foot rest at 15cm. above the floor. An alternative foot rest should also be provided under the bench so that the student may adopt an alternative position for the legs when the use of the stool rest becomes tiresome. Figure 1, illustrates these points.

A further and important aspect of laboratory bench design that is frequently overlooked is the need for provision of free knee space between the top of the seat and the underside of the bench top. This space should be such as to allow the student easily to move to different sitting positions. This requires the bench top to be kept as thin as possible and supporting members either of very small dimensions or located well back from the bench front, leaving free space for the knees.

Where the laboratory is used for a substantial amount of lecture and demonstration work by the teacher, as well as experimental work by the students, then back rests to stools will be found to contribute substantially to comfort. However, experience of prototype stools designed in the Institute and used in laboratories where the bulk of the work comprises student experiments, suggests that the back of the stool impedes movement and stools without backs are preferred by students.

The final consideration in designing the shape of the laboratory bench is the area of working surface to be provided. This is governed by two factors. First, the reaching capacity of the student and, secondly, the size of the experiments to be made. The second consideration need not concern us here as, whatever area is finally selected using the first criterion can be made to meet the second by joining benches together so that, for example, optical experiments that may require two or three metres of bench length can be easily carried out.



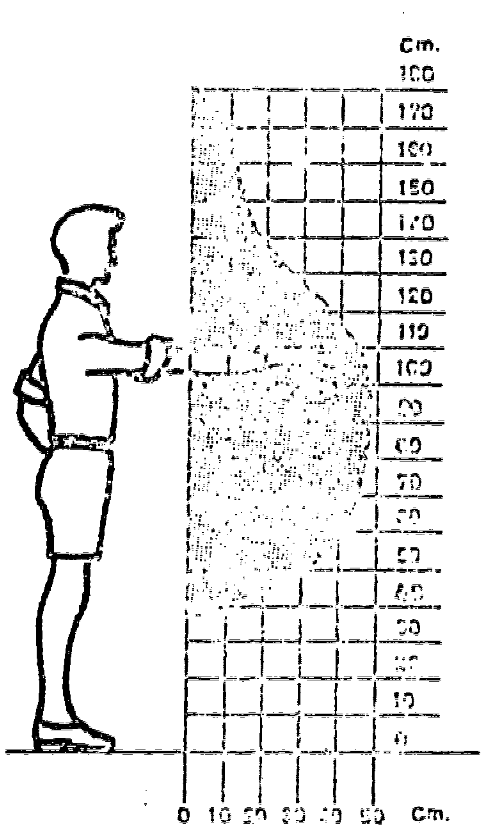
A SITTING PUPIL CONVENIENT
B -"- -"- MAXIMUM
C STANDING -"- -"-

LIMITS OF REACH AT LABORATORY BENCH
fig. 2

Measurements of seated 14 years old students show that the length of bench that can be used is about 60 cm. This length permits of notetaking or writing. Fifteen centimetres should be left between one student and the next for "elbow room". The design student, leaning forward and reaching out from the stool can conveniently handle apparatus up to a distance of 50cm away from the bench edge. The same student standing can reach apparatus at a distance of 58cm. comfortably. The limit of reach for seated students is 63cm and for standing students, 84cm. The possibilities are illustrated diagrammatically in Figure 2.

4. The Student and Storage

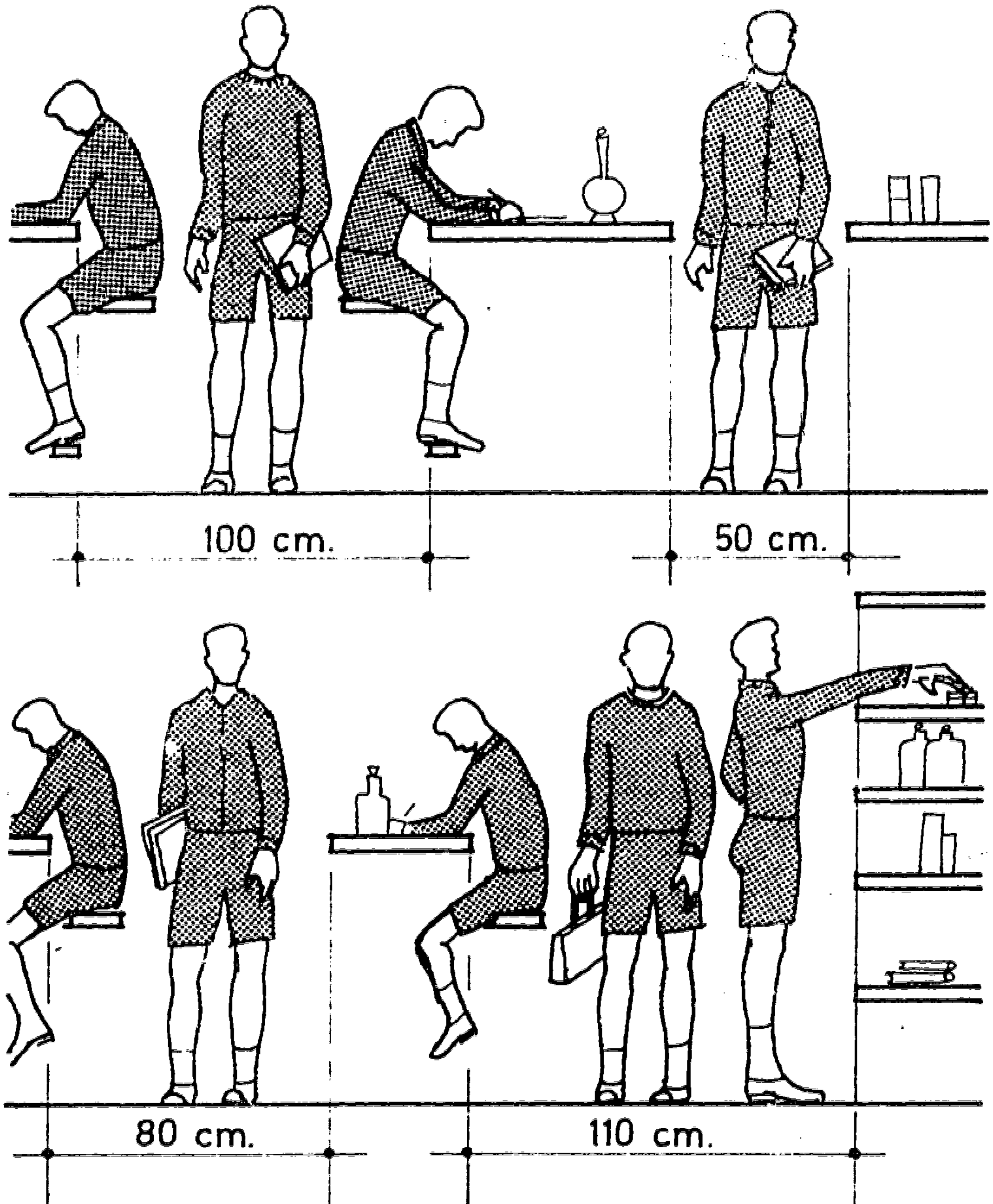
From the foregoing section, it will have been concluded that the student's bench is an unsuitable place for storage. The space beneath the bench is left free for knee and leg movement and the surface is for working. Storage shelving has thus, to be located elsewhere in the laboratory. The most obvious places for this are the walls. In locating storage units on walls, however, account will have to be taken of the need for chalk and pin-up boards, ventilation openings and doors. Indeed, in hot, humid climates, where both the external wall and the wall facing it are open to provide the ventilation needed for thermal comfort, the only vertical surfaces available for storage are usually the cross walls. There is a temptation in such restricted conditions to provide storage shelves and cupboards which are either too low or too high for convenient use. The solution to this problem (which is discussed more fully below) is in the provision of a storage room for all but the most commonly used items which are kept in sets either on movable trolleys or in fixed units conveniently arranged at low level in the laboratory.



CONVENIENT REACHING AT SHELVES fig. 3

What, then, are the convenient heights above floor level for storage shelves? First, the item should be easy to see standing, secondly, it must be easily reached and, thirdly, easily lifted from the shelves. At 180cm. above floor level, whilst it will just be possible to reach an item on a shelf, it can only be lifted off the shelf if it is light and easy to grip. At shoulder level it will be possible to retrieve an item from a shelf 50cm. deep. Items stored below 39cm. above floor level will require substantially more effort to lift, due to the need to bend, than items stored slightly higher.

These factors have all been considered in Figure 3 which indicates (in the darkened area) the most convenient zone for storage. What sort of items should be stored in the laboratory on wall shelves is considered below in the section on equipment and storage.

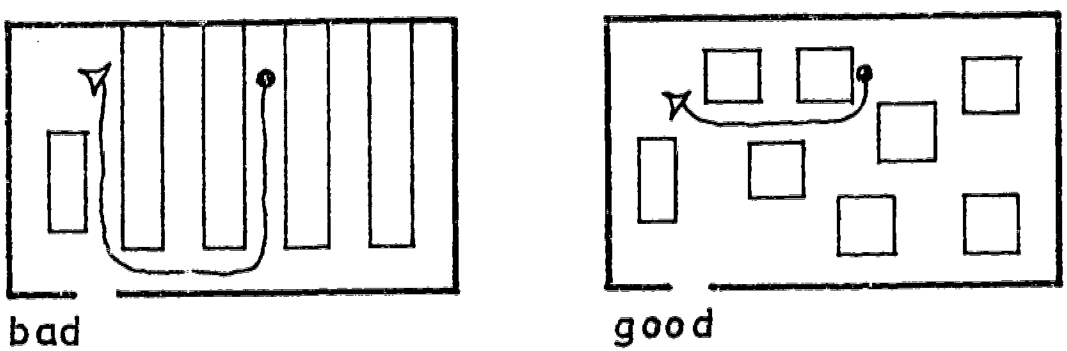


MINIMUM DISTANCE BETWEEN FURNITURE
fig. 4

5. The Student Moving Around the Laboratory

The character of school work today is more informal and flexible than it used to be. In science teaching and learning in particular students move about much more as activities change, often during one period in the laboratory from group work to discussion to short demonstration and so on. The design of the laboratory must be such as to facilitate this movement. Figure 4 indicates some significant minimum dimensions in this respect.

In addition to providing space for movement, however, it is also important to avoid the long, narrow passages between rows of fixed benches that are so characteristic of traditional laboratories and so inhibiting to easy movement. Figure 5 suggests how bench arrangements can permit of easier movement in a modern laboratory.



EASE OF MOVEMENT IN THE LABORATORY

fig. 5

Laboratory work, however, includes a number of fine tasks such as dissection (in biology), magnetism and weighing (in physics and chemistry) and colour discrimination (in chemistry). These finer tasks require more light than would be necessary for reading and writing. It is recommended therefore, that the general level of illumination in a laboratory should be such that it is possible to obtain substantially higher illumination levels by moving nearer to windows where levels of 500 lux should be easy to obtain. 150 lux is an adequate illumination level for the rest of the space. The Institute's School Building Digest No.9 shows methods of calculating window sizes to give predetermined illumination levels in laboratories.

B. SCIENCE EDUCATION

"If you give a man a fish, he will eat once. If you teach a man to fish,he will eat for the rest of his life". (Kauan-tzu, Chinese Philosopher, 3-4th cent.B.)

1. General

One of the first questions to be asked by a designer of a laboratory is, "What is the purpose and function of the room?" The answer might be, "The laboratory is a place in which students are supposed to learn and to develop certain attitudes and aptitudes in relation to science. The aims and objectives of science teaching and learning are set out in the curriculum which may be elaborated in detail schemes of work and possibly supported by textbooks". As far as laboratory design is concerned, the realization of science teaching and learning involves the following considerations:

2. Practical Work

An important activity in the laboratory is practical work by the students. In the general purpose laboratory, this will be, somewhat naturally, more varied than in specialised laboratories for physics, chemistry or biology. Activities may include:-

- individual work or work in small groups involving perhaps, microscopes;
- work in larger groups on mechanics experiments;
- chemical experiments requiring heat and water;
- physical experiments requiring electricity;
- dissection work requiring very good illumination;
- mechanical experiments such as the triangle of forces for which lower illumination levels will suffice;
- lengthy experiments such as the growing of plants;
- short experiments such as the explosion of a balloon;
- balance work and optical experiments requiring stable surfaces;
- free-standing exercises requiring floor space, such as experiments in centrifugal force.

Obviously the spaces provided for such a wide range of activities need to be designed very carefully and an inherent characteristic of the design solution must be flexibility to allow the adaptation of the laboratory for the needs of each different type of experimental activity.

3. Able and Advanced Students

Whilst most activities follow the patterns set out in the schemes of work, exceptionally able or advanced students are often encouraged to extend their understanding of various sections of the syllabus by working on their own. Often this sort of student will return to the laboratory to continue work after school hours. Some space should be provided in the laboratory by the designer for these students. They will usually be few in number and the space may be small. Its provision is, however, important.

4. Science Clubs

One of the ways of encouraging interest in science is through science clubs. Clubs permit the student to interest himself, either individually or as a member of a small group, in aspects of science for which time is not available during the normal science periods. The main impact of club activities on laboratory design is in the need for separate storage. Case Study I indicates a solution to this problem.

5. Group Sizes

Many factors determine the number of students working together as a group on a single experiment. Although education should be directed towards the individual, one of the best ways of doing this may be through discussion with and learning from peers. Moreover, ability to work in a group is itself one of the desired outcomes of the education process. Much work has been done on the psychology of working in groups and it will be sufficient for the present purpose to say that groups of up to about ten in number pose no special problems. The importance of group work in many countries springs, however, not only from educational considerations but also from the need to share scarce equipment between several students. (There is often not enough equipment for individual work to allow the student to study profitably on his own.)

The general conclusion that is drawn from the foregoing is that the design of the laboratory should be such as to permit working in groups of various sizes. Different situations will result in different numbers in the groups and this, as is shown later, has an effect on the design of work stations in the laboratory.

6. Demonstrations

Whilst there is a trend towards increasing the amount of practical work to be done by the students, demonstrations of selected material by the teacher will continue to play a significant part in the total learning process. There may also be other reasons for demonstrations by the teacher such as when there is an element of danger in the experiment or when a particularly delicate or expensive piece of equipment is involved.

Normally, however, a demonstration may be given either to prepared the students for a subsequent experiment that they themselves undertake, or in recapitulation and reinforcement of work that the students have already completed.

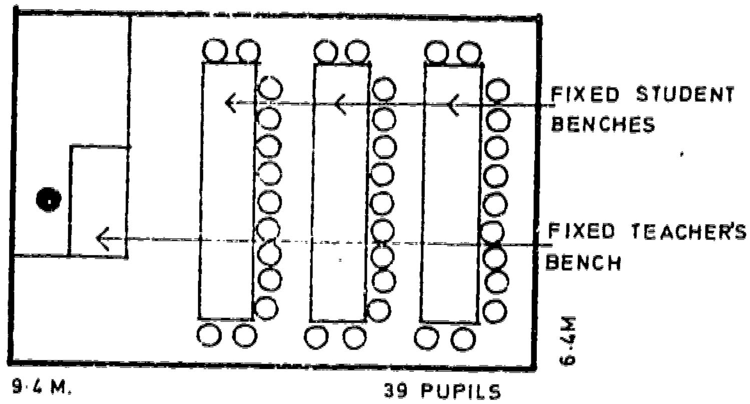
Whatever the case, the designer must ensure that the demonstration can easily be seen and the closer the view the better. Some solutions to this problem are suggested in Figure 6.

7. Teacher's Work Station

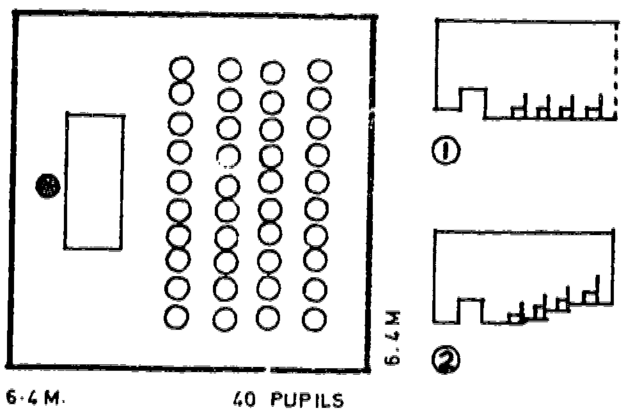
There is no real need for a fixed and separate demonstration table as demonstrations can easily be given on one of the student benches. The teacher does need, however, a place to prepare and to mark students' work. This teacher's work station should be in the laboratory and in such a position that a good view can be obtained of all student activities. There is no longer any need, at least from a functional view-point, to locate the teacher's table at the front of the laboratory as was the practice in traditional laboratory design of the past. Indeed, the role of the teacher as a co-worker rather than a mentor makes it important to locate him among, rather than in front of and above, the children.

8. Teaching Aids

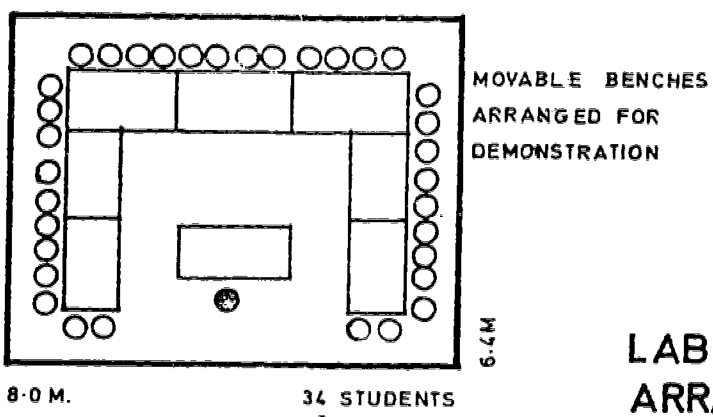
The most important aid in the laboratory continues to be the chalkboard which is used for tables, diagrams, and the like. There are, it is true, other devices, such as the overhead projector, which are almost equally useful, but they require power and are much more expensive than chalkboards to buy.



traditional layout



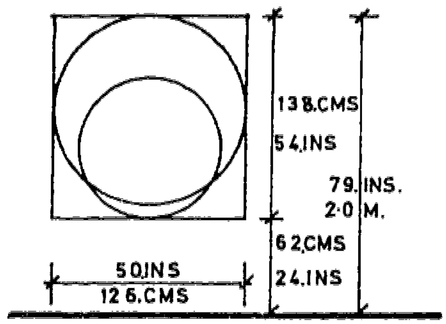
spacial area ① or room ②
for demonstration



rearrangement for
demonstration

LABORATORY BENCHES
ARRANGED FOR
DEMONSTRATION
fig. 6

For the Asian Region, for some while to come, the chalkboard will thus continue in common use. What is important is that chalkboards should be provided of sizes and in positions where they will be of the greatest value. The demonstration area clearly requires a board and Figure 7 shows suitable minimum sizes and heights.



CHALK BOARD FOR SECOND LEVEL SCHOOLS

fig. 7

In science teaching and learning, however, where the teacher is frequently working among the students at their laboratory tables, chalkboards can usefully be fixed at strategic points around the teaching space for intermittent use in discussing a point. Where doors are flush panelled, for example, they can be painted with chalkboard or other matt paint and provide good surfaces for writing or sketching. Flush cupboard doors are also useful in the same way.

Science teaching makes considerable use of prepared charts and drawings of plants, animals, periodic tables and the like. Rails for hanging this material should be provided in as many places as possible in the laboratory. Part of the area near the chalkboard, if finished in softboard, will also suit this purpose admirably.

9. Services - water, heat and electric power

i) Water and waste liquids

Running water from a tap is no doubt, the most convenient form in which this particular service can be introduced into a laboratory. The difficulty with piped water supplies is that they are fixed in position. The fixing of a service runs counter to modern ideas of teaching and learning which demand flexibility in the laboratory. Two solutions to this problem are in use. The first is the location of the water outlets and sinks around the laboratory perimeter from which the students can collect and carry water to their work station which can itself be a movable bench. Secondly, a few small isolated bollards at which water, electricity and gas are available, can be fixed at strategic points about the laboratory floor and the movable benches arranged as desired around them.

Study of teaching schemes may suggest, however, that the requirements for water are often very much less than might be thought. Including an allowance for washing up after experiments, in the schemes for chemistry in one country of the Region, 8 litres was found to be the maximum requirement for a group of five students for an entire term. Clearly there is no prima facie case to be made for piping water to a laboratory with such a small consumption. Two or 3 litre aspirators, filled from time to time from a convenient well or other clean source, will provide all the water that is needed in that particular situation.

This conclusion concerning water supply is very important for the Region in which there are a very large number of rural schools with no piped water and in which also the cost of an installation would often be sufficiently high to prohibit the teaching of science, were there no alternative sources of supply.

Much the same reasoning can be applied to the problem of drainage of laboratory wastes from sinks. Fixed sinks and drainage are a restricting factor in a laboratory for which flexibility is a major design criterion and, moreover, are expensive. Where it can be demonstrated, by studying of teaching schemes that the real consumption of water is small, then a simple plastic bowl is a good substitute for a ceramic fixture. Waste water from the bowl can be thrown out into a convenient drain at the end of every day. (Plate II)

[illegible]

A spirit lamp is a convenient and adequate tool for heating a test tube where supplies of spirit are readily available, (Plate III). Where they are not, then a small primus stove can be used for heating both test tubes and beakers. (Plate IV) The bunsen burner is, of course much more convenient than either a lamp or a primus stove. Fuel for a bunsen burner is, however, the main problem. Where gas is not available, then a type of burner fed under pressure by methylated spirits from a container hung high on the wall is one solution, whilst another is the use of gas generator or of bottled gas. Town supplies of gas are likely to be very rarely available in the Region.

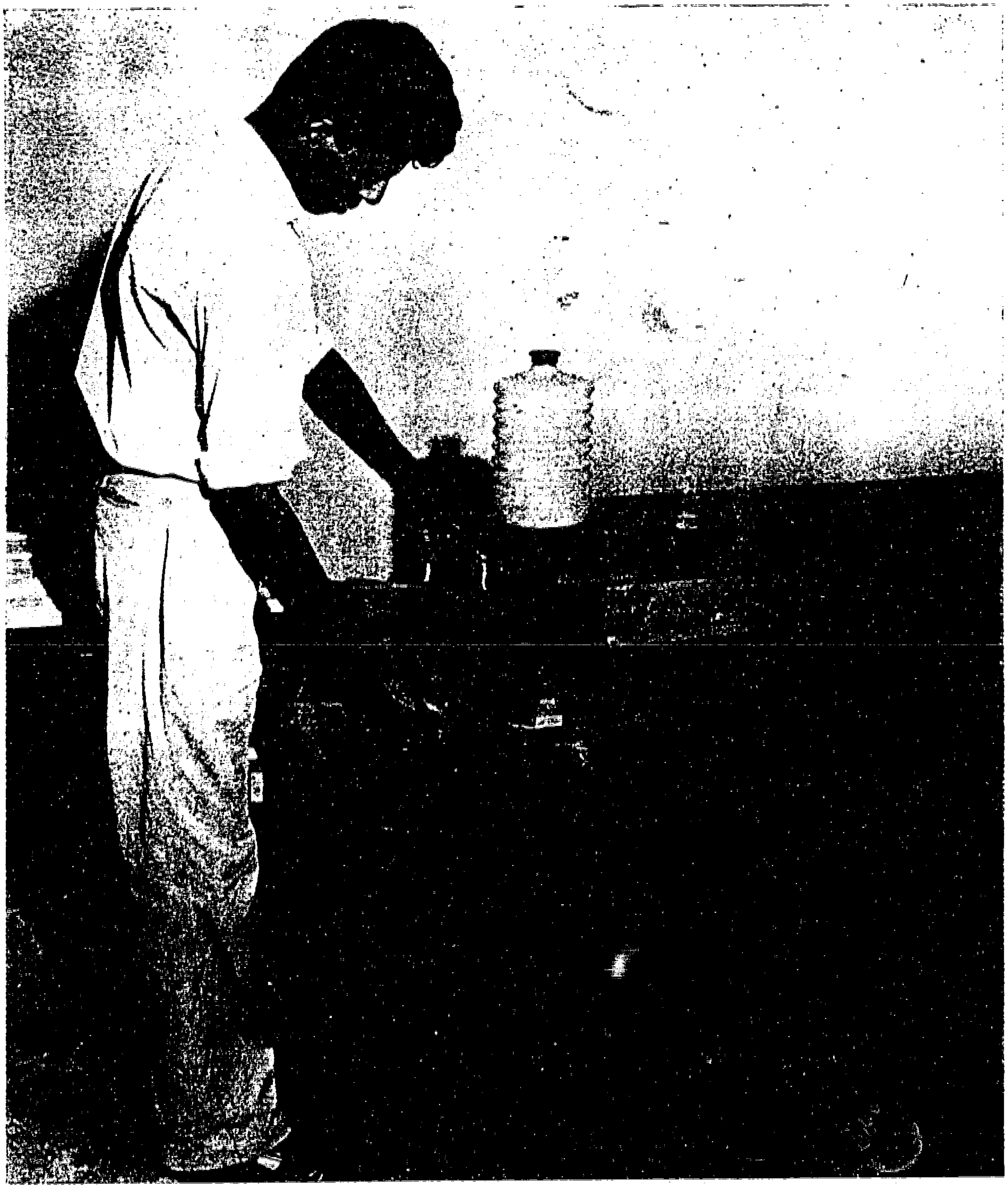


Plate 2 Portable sink avoids expensive fixed water connections.

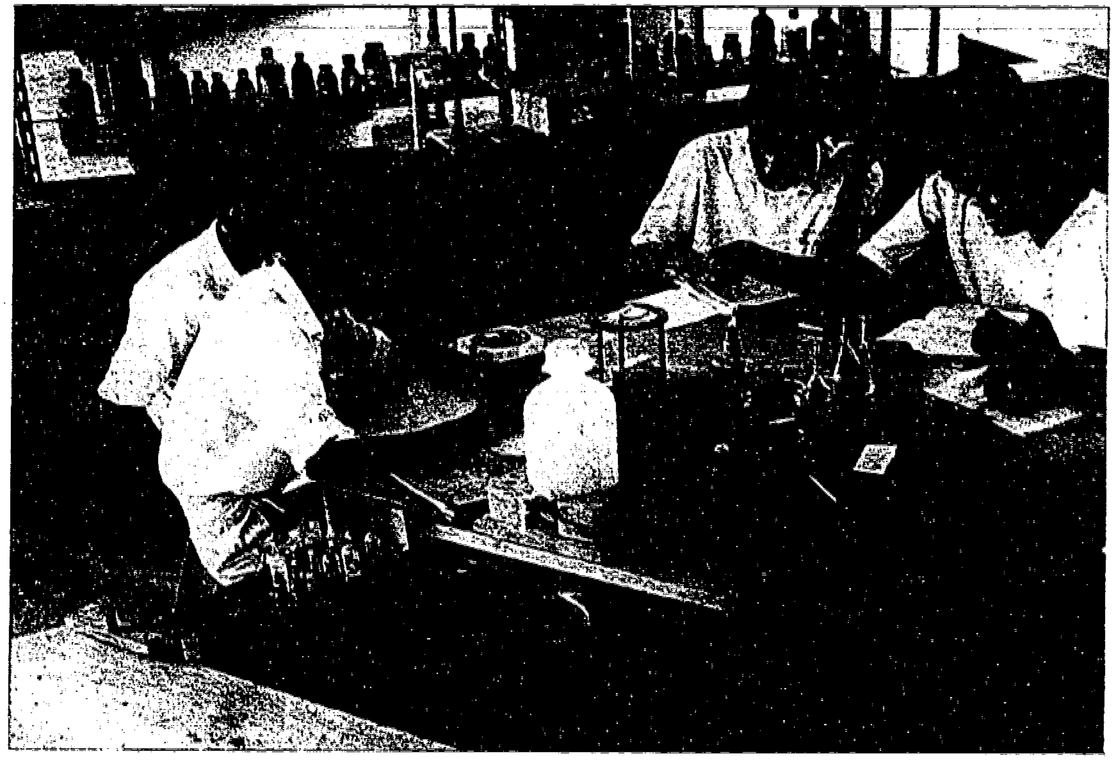


Plate 3 A spirit lamp is convenient for heating test tubes.

Plate 4 A primus stove provides more heat.

Where electricity is available and not gas, then small immersion heaters can be used for beakers. The difficulty of providing a suitable heat source in a rural situation is, as will be seen from the above, very considerable. The introduction of semi-micro chemistry has much to recommend it if only for the reason, that all heating can be arranged with a small spirit lamp.

iii) Electricity

As with gas the water supply, perhaps the first and most important enquiry to be made by the designer is, to what extent the facility is used. Very little electrical power is needed for chemistry and biology teaching and learning and, moreover, its use is infrequent. Physics of which the study of electrical phenomena forms a major part, has an obvious and greater need for this service in the laboratory. Even so, for lower secondary education there are very few experiments indeed that cannot be satisfactorily carried out with dry cells or accumulators. These can, because they are portable, be located at any convenient place in the laboratory and are easily recharged in areas where motor vehicles normally operate. There is virtually no case to be made for the installation of electric mains power in laboratories of the type under discussion in this paper and, indeed, mains power is not only unnecessary, but can be dangerous.

10. Equipment and its Storage

There are three questions that have to be considered in connection with the design of storage facilities for laboratories:-

i) What is to be stored?
ii) Where are items to be stored?
iii) How are items to be stored?

i) What to store

The main items to be stored are, of course, those required for demonstration by the teacher and experimental work by the students. Most education authorities have standard lists of equipment needed and supplied for science teaching. There is often a difference, which varies from country to country, between the ideal lists and the equipment actually provided. Sometimes the lists represent what is required by the curriculum and bear little, if any, relationship to the financial resources available for equipment purchase. Occasionally an education authority will produce interim lists which are related to its resources at a point in time and to which it is anticipated that substantial additions will be made when more money is available. Sometimes, teachers are encouraged as a matter of science teaching policy, to use local material in experimental work and the students may make equipment for experiments they have designed themselves. In the field of biology, in particular, the collection of local material may vary considerably from school to school, even in the same district due to the varying degrees of enthusiasm of the teachers and students. In one school in northern India, for example, the students found a dead camel the skeleton of which was, after preparation, mounted for study in the laboratory. This may be a somewhat extreme example of enthusiasm but it well illustrates the point that what is set down in the official lists of equipment and teaching aids is not necessarily all that will be found in the laboratory and indicates the need for storage of unforseen items.

The best way of determining what is to be stored finding out what sort of storage problems are likely to be faced, is to set out all the issued equipment and to measure the volume of space occupied, noting any items that by virtue of their shape or other characteristics, require special types of storage arrangements such as racks, drawers, shelving, hooks etc.

In a trial of the space requirements for the standard chemistry teaching equipment for Ceylon, for example, it was found that 2.2 sq.m. of shelving was needed for all the items, tightly packed. Spacing the items out for convenience of selection and handling suggested that some 12 sq.m. of shelving was a practical requirement.

In addition to equipment, storage space should also be provided for the many books and bags that are brought into the laboratory and which, when placed on the laboratory benches, reduce the effective working space and create a hazard in respect of experimental work.

ii) Where to store

A good general rule is that items which are most commonly used should be more easily accessible than those that are not. This gives an obvious saving in both time and energy. The implications of this statement have been carefully studied with respect to the Ceylon Science Equipment Lists and frequency of use tables (as indicated by the teaching schemes) prepared in respect of teacher demonstrations and student experimental work. Table II gives the 20 items most frequently used by the students in carrying out the experiments recommended in the schemes.

TABLE II- THE 20 MOST COMMONLY USED ITEMS IN THE CEYLON SCIENCE SCHEMES OF WORK FOR GRADES IX & X*

(Figures indicate the number of occasions at which the different items are to be used.) Figures within brackets indicate the maximum numbers of the same item needed at one occasion. The total syllabus contains 396 periods .

Item	Chemistry		Physics		Biology		Total
1. Test-tube 15 x 150mm	138	(20)	-	-	-	-	138(20)
2. Test-tube 25 x 150mm	38	(06)	-	-	10	(03)	48(06)
3. Bunsen burner (Heat source)	27	(02)	05	(01)	16	(01)	48(02)
4. Holders test tube	33	(04)	-	-	10	(01)	43(04)
5. Stands test tube	25	(02)	-	-	16	(01)	41(02)
6. Thermometers 0° - 110°	03	(01)	14	(02)	03	(04)	20(04)
7. Test tube 9 x 70mm	18	(04)	-	-	-	-	18(04)
8. Beaker 250 ml	11	(01)	04	(02)	03	(02)	18(02)
9. Cork assorted	10	(06)	-	-	08	(02)	18(06)
10. Cork borer	16	(01)	-	-	-	-	16(01)
11. Hand-lens	-	-	-	-	16	(06)	16(06)
12. Pins optical	-	-	14	(04)	-	-	14(04)
13. Rubber bungs assorted	12	(04)	-	-	-	-	12(04)
14. Cover glass 15cm x 15cm	-	-	-	-	12	(02)	12(02)
15. Accumulator	-	-	11	(01)	-	-	11(01)
16. Glass slides 3" x 1"	-	-	-	-	10	(06)	10(06)
17. Beaker 400 ml	02	(01)	03	(01)	04	(01)	09(01)
18. Stands-laboratory	-	-	09	(01)	-	-	09(01)
19. Measuring cylinders (Graduated)	05	(01)	-	-	03	(01)	08(01)
20. Glass tubing	-	-	-	-	08	(-)	08(-)

* - *original list which contains all items from the Ceylon list of Science equipment prepared by ARISBR by the Curriculum Development Centre, Ministry of Education, Ceylon.*

In this case it might be convenient for the first five items to be kept at the laboratory benches and the rest of the items in the list on shelving in the laboratory except for the last four items, the use for which is so very infrequent that they would be kept with even less frequently used items(not given in the table) in the laboratory store.

It may be worth mentioning at this stage that, in some countries of the Region, science equipment is issued to the teacher and that he or she is personally and financially responsible for its safe keeping. In such situations it is a matter of common observation that the teacher is very reluctant to use the equipment of all and even more reluctant to let the students use it for, if anything is broken, then a deduction may be made from what is usually, in such circumstances,a very small salary. This paper offers no solution for such situations which can only be resolved through appropriate administrative action and through building design.

Assuming that the education authority has created an administrative environment in which the teacher is both able and willing to make full use of all the equipment provided, then it will be possible to store certain items of equipment in the laboratory in the open and in a position where they can most conveniently be used. The nature of the items to be stored in this way will be determined from frequency of use tables. The location of the items close to the students' benches can be arranged as follows:-

a) in fixed storage units against which the movable laboratory benches can be placed in any desired position. The storage unit could include services such as water and drainage, gas and electricity. The units would be carefully located so that they in no way obstruct the flexibility of the laboratory.
b) in mobile storage units or trolleys which can be moved to any desired point in the laboratory.

Both solutions are illustrated in the case studies that follow.

Storage of the somewhat less frequently used items of equipment in the laboratory is best arranged along the walls in cupboards or open shelves as appropriate and at the heights suggested earlier in this paper. The Ceylon equipment list contains 58 items which are used by the students less than twice a year and these, together with the equipment specially provided for teacher demonstration, can be stored in a separate space which may also incorporate facilities for preparatory work by the teacher prior to each lesson.

iii) How to store

Earlier in this paper, suitable heights for convenience in lifting items from shelves were discussed. Additional comments on special aspects of storage are given below:-

a) Large bottles in which liquids are stored in bulk before dispensing into more convenient smaller bottles, should be stored at floor level and, if they contain corrosive liquids, it would be wise to provide sand trays in which to stand them.

b) Poisons, small and exceptionally expensive items of equipment should be kept in lockable cupboards.

c) As there is little uniformity in the vertical dimensions of much science equipment, all open shelving should be adjustable for height. Larger items should be put on the lower shelves and smaller items on the upper.

d) A suitable length of 10cm. wide shelving for small bottles will be found most useful whilst the rest of the shelving should be 40 cm. wide. The uppermost shelf in Figure 3 could conveniently be used for small bottle storage.

PART II - CASE STUDIES

A - A LABORATORY FOR INTEGRATED SCIENCE IN MALAYSIA

1. Summary of relevant Information

i) The laboratory will be used by Forms I-III, with children of 13-15 years of age.

ii) Number of pupils per class: 40-45.

iii) The syllabus indicates three types of practical work:

P = Small group or Individual work 63%
S = "Station" method 1/ 3%
D = Demonstration Experiment 34%

iv) The Science section, Ministry of Education, Malaysia, has indicated that the students will work in pairs, but a group of up to four in number at one bench is acceptable.

v) The use of visual aids is indicated in different parts of syllabus.

vi) Water, bottled gas and electricity is available in all schools.

vii) Water is used in about 25% of the experiments, the use being somewhat infrequent. (In addition to this, water will be needed for cleaning the equipment). The "standard" Malaysian laboratory has 14 sinks with running water.

viii) The scheme of work indicates that heat is required intermittently for about 30% of the experiments. Twenty four burners are included in the equipment list which indicates that every pair of pupils are provided with this item. The "standard" laboratory has 22 double-gas-outlets.

ix) Electricity is used heavily in the section of the syllabus dealing with electricity. All sorts of power sources are mentioned. Mains power, dry, cells, batteries, etc. Mains power is only used

---

1/ *Experiment set up by the teacher and completed by students.*

for demonstrations and station work; dry cells are used in all other types of experiments requiring electricity. Accumulators are included in the equipment list as optional items. The "standard" drawings do not indicate any electrical outlets.

x) Some parts of the syllabus, especially section 13 "support and movement" might need free floor space for experimental work.

xi) The concrete building structure shown in the drawings and in which the laboratory is to be located, has a span of 7.6m and a distance between the columns of 3.0m.

xii) A combined store and preparation room is attached to the laboratory. Where two laboratories are provided one storage/preparation room is shared by the two laboratories. Cupboards and drawers provided in the student benches are not normally used either by the students or for storing.

2. *The Proposals*

a) For the student's work station

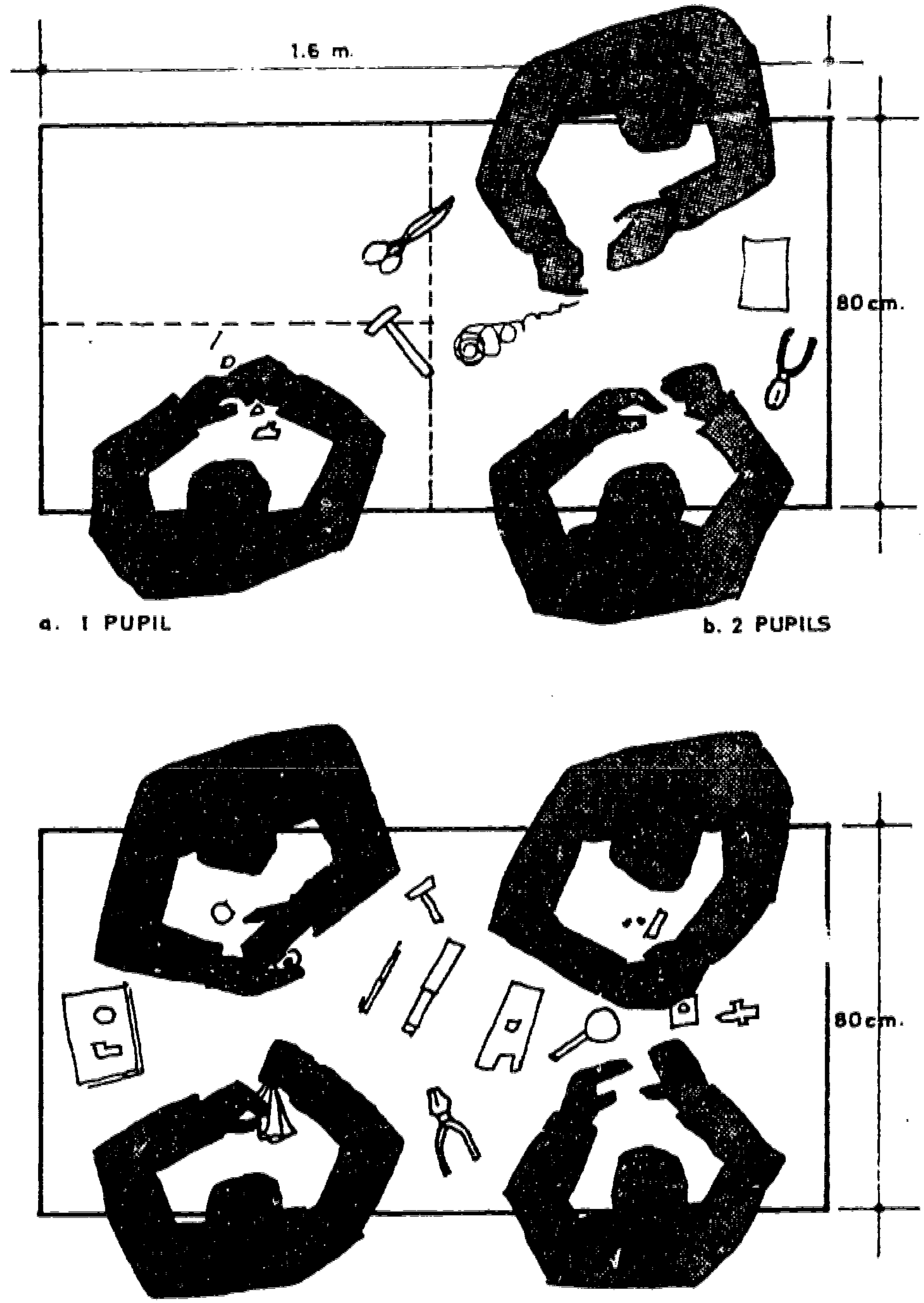
This should provide adequate space for pupils to work individually, in parts and in groups of up to four in number.

b) The bench worktop

Studies have been made in the Institute of the reaching capacities of sitting and standing 14 year old pupils. An estimate of the space required for experiments on the worktop has also been made. The outcome of this, together with consideration of the group sizes mentioned above is a bench top of plan dimensions 78.5 x 157 cm. The bench surfaces available for the different groups are shown in Figure 8. The best way for working in pairs is probably that shown in Figure 8(b), but it is, of course, also possible to work side by side as in Figure 8(c).

c) The height of bench and chair

The height of the worktable should be 76cm. This is a convenient height for a standing 14 year-old pupil. For convenient sitting at this table the measurements of the chair should be as indicated in Figure 1.



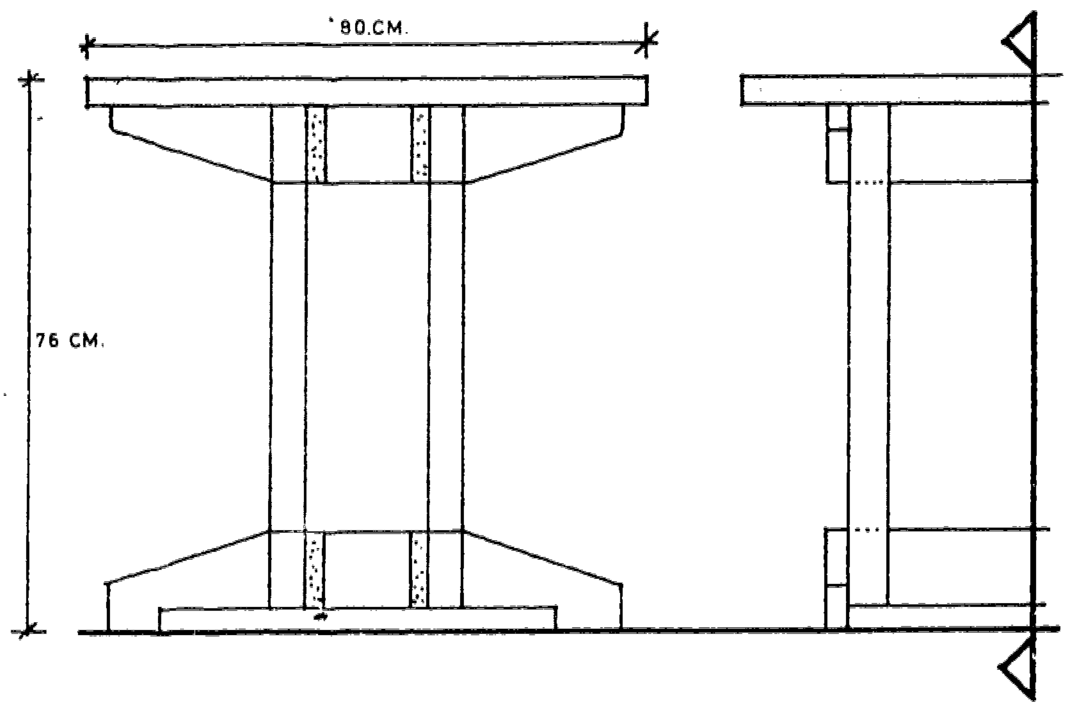
DIFFERENT STUDENT GROUPINGS AT WORKTOP 5' 2" X 2' 7" fig. 8

d) The stool

Detailed drawings of stools were not provided by the Institute as it was assumed that a stool with the measurements indicated in Figure 1 would be available on the Malaysian Market or that an existing design could easily be adapted. It is important, however, that the stool be made in light metal as it should be easy to move. The stool should be made without back as this is more convenient for movement.

e) Bench construction

It is important that enough knee space is provided between the chair and the bench top. This means that the traditional wooden bench construction with a lengthwise support at the edges is undesirable. Figure 9 shows a design for a bench made of wood, the lower lengthwise batten of which can function as a second foot-rest for the pupils.



LABORATORY BENCH: SECTION SHOWING FREE KNEE SPACE AND FOOT RAIL fig. 9

3. Activities

The laboratory should provide adequate accommodation for the following activities:

a) Individual experiments	(40 pupils)
b) Work in pairs	(20 pairs)
c) Work in groups of four pupils	(10 groups)
d) Work in large groups of 8 to 10 pupils	(4 to 5 groups)

- *(This group size is not clearly proposed in the syllabus but it is assumed that some of the experiments might well be carried out in larger groups. These groups sizes are equally convenient for discussions.)*

e) *Demonstration*

i) Some demonstrations need to provide a close view for the students, who should thus be accommodated within quite a short distance of the demonstration bench;

ii) During some demonstrations students will have to take notes.

f) *Lectures*

The pupils should be able to see and hear the teacher, see the chalkboard and take notes.

g) Films and slides.

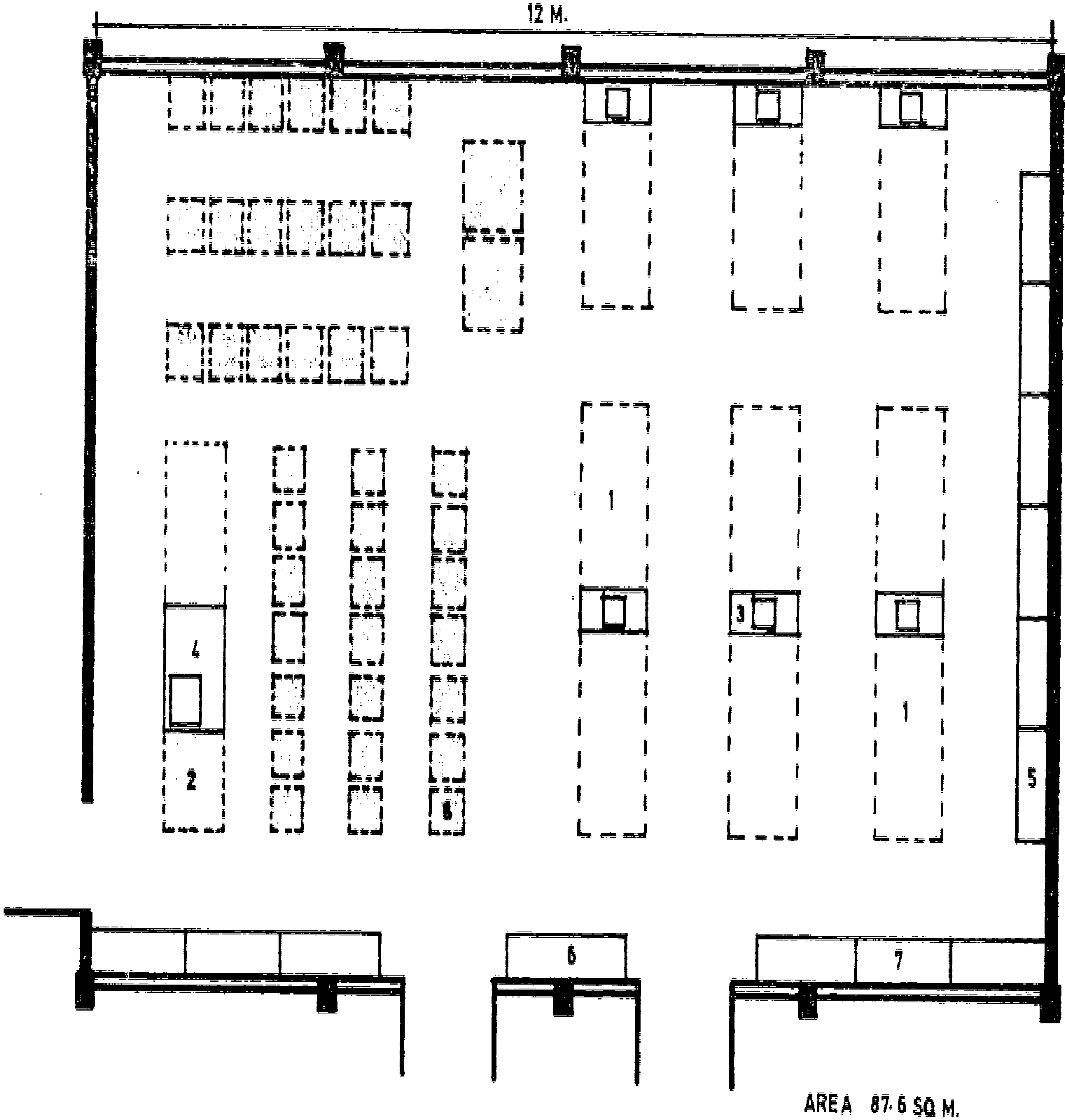
4. The Layout

Two proposed layouts A and B are shown in Figure 10. Layout A, is based on the standard Malaysian Laboratory unit (89 sq.m.). Laboratory B, is one bay smaller (67 sq.m.).

5. Furniture

The furniture can be divided into four categories:

a) Fixed furniture
b) Furniture to be moved occasionally
c) Furniture which can be moved easily
d) Miscellaneous.



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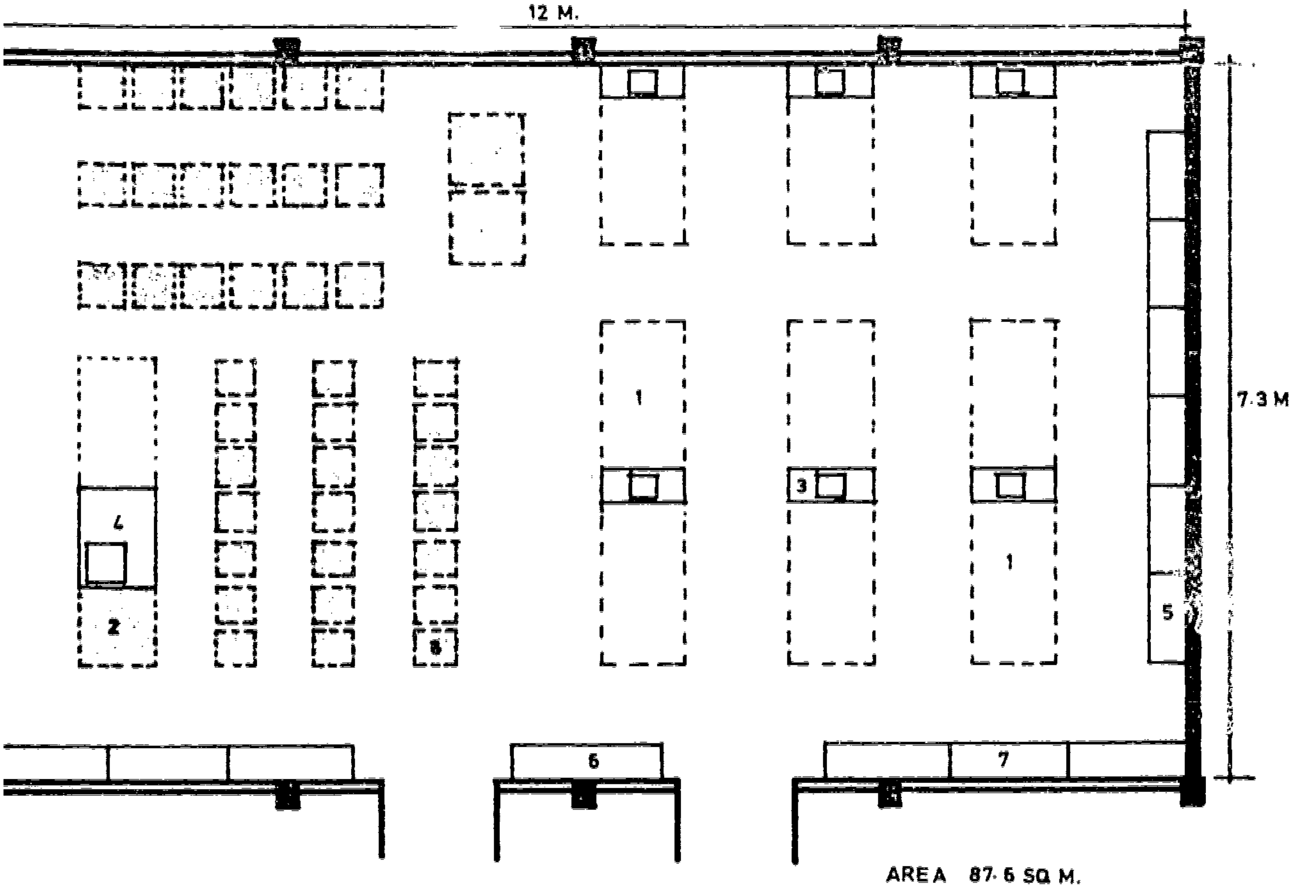
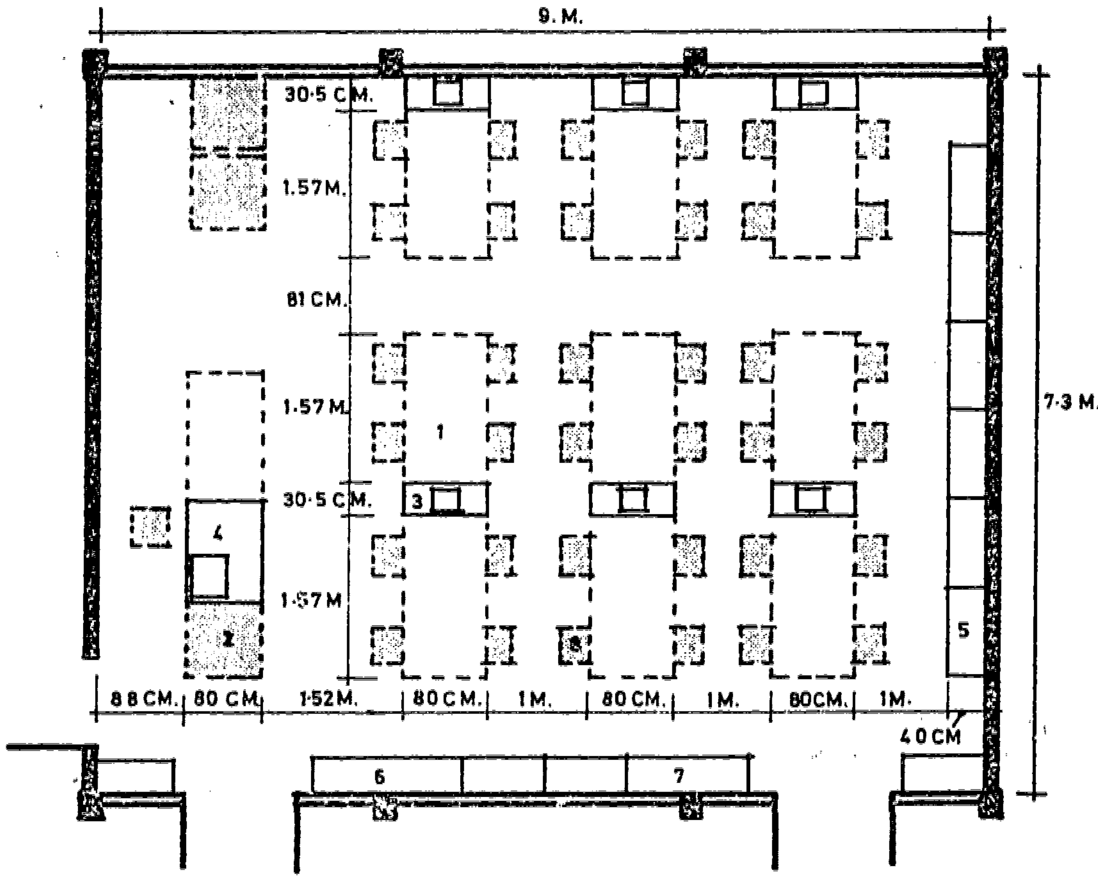
LABORATORY - A fig. 10 A



LABORATORY - A fig. 10 A



AREA 65 SQ.M.

1 WORK TABLE (9)
2 - - ON WHEELS (5)
3 SERVICE UNIT PUPILS' (6)
4 S - - TEACHER (1)
5 OPEN SHELVES FOR EQUIPMENT (1)
6 - - - BAGS AND BOOKS (1)
7 STORAGE WITH DOORS (8)
8 CHAIRS (45)

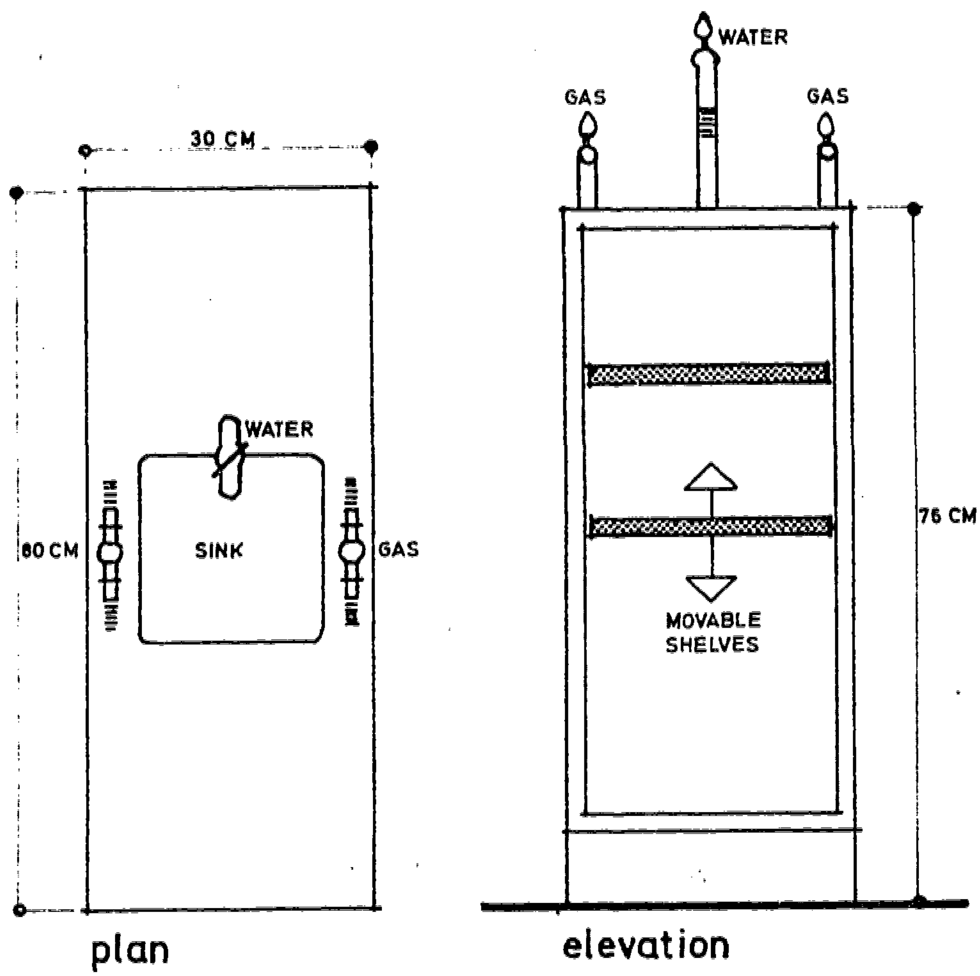
FIXED FURNITURE
MOVABLE
OFTEN MOVED

LABORATORY - B fig. 10 B

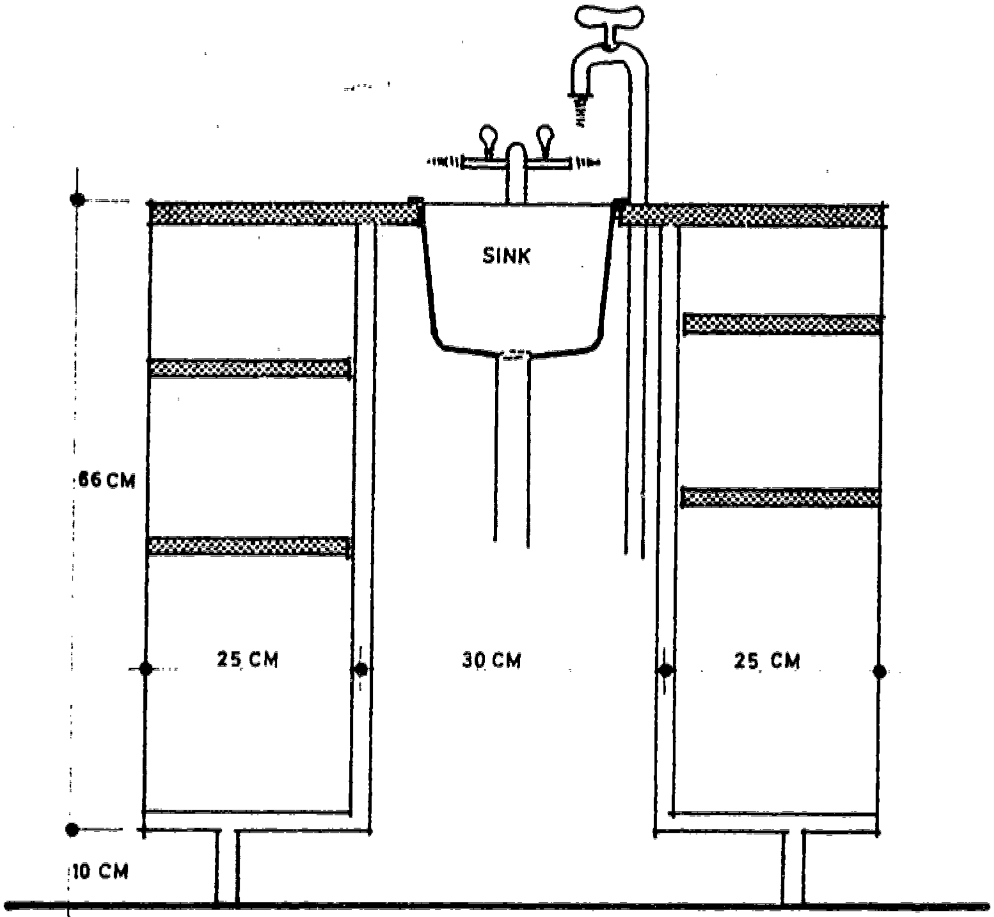
a) Fixed furniture

i) The service units - The furniture that *has* to be fixed is that containing services including water, power, gas and waste. Six service units for the students and one for the teacher have to be provided.

The student's unit, (Figure 11) includes running water outlets with a small sink and a gas out-



STUDENTS SERVICE UNIT fig. 11a



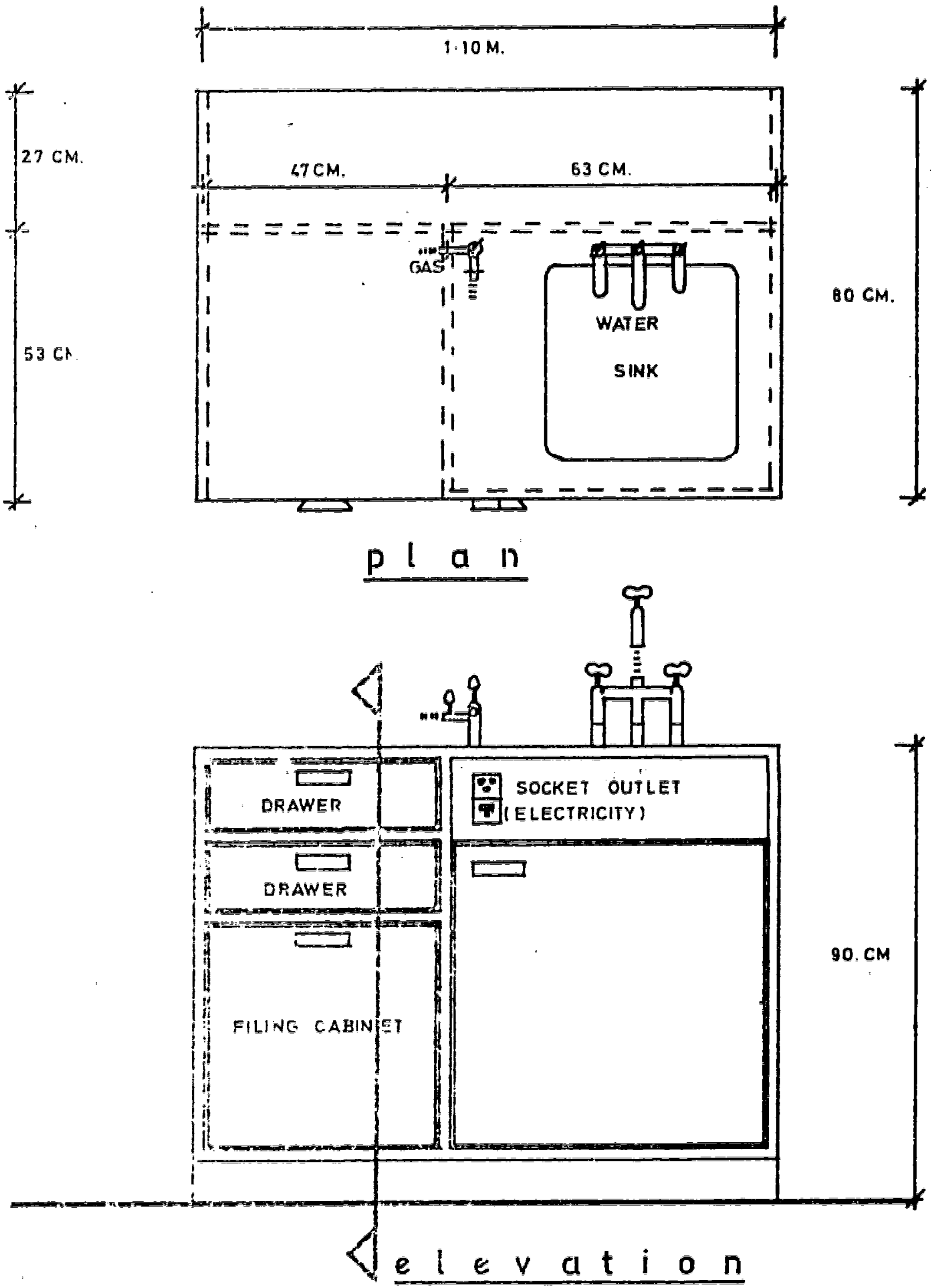
section

STUDENTS SERVICE UNIT fig. 11 b

let for every two students. It also includes some open shelves for commonly used items such as test tubes, beakers and the like.

Electrical outlets are not seem to be needed according to the syllabus, but if it is regarded as desirable by the science teaching inspectorate, outlets could easily be included in the service unit.

The teacher's unit is larger in size and includes in addition to the services at the pupils' units, power outlets, lockable drawers and filing cabinet. As the whole depth of the unit cannot be utilized for the teacher's side, some shelves for books and periodicals are provided, facing the class. (Figures 12A and 12B)



TEACHER'S SERVICE UNIT fig. 12 A

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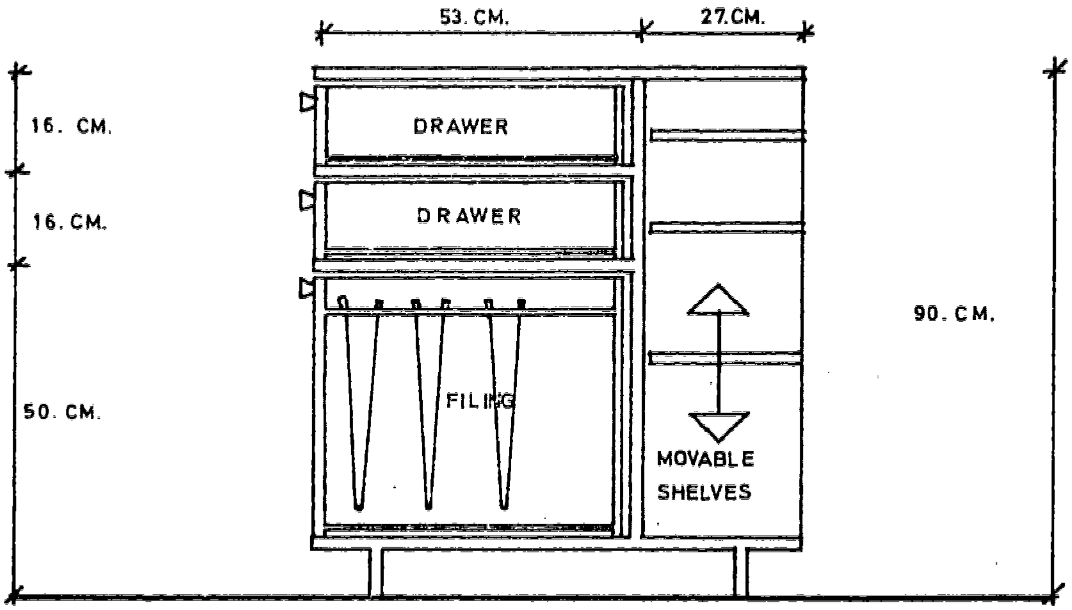
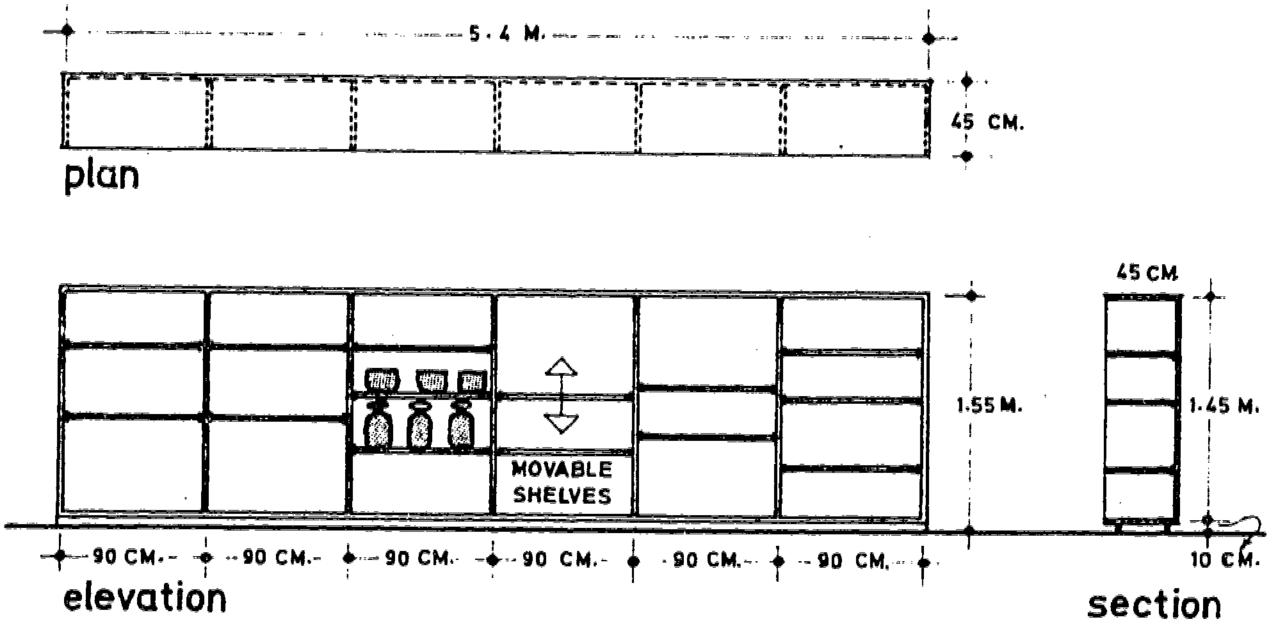


section

TEACHER'S SERVICE UNIT fig. 12 B

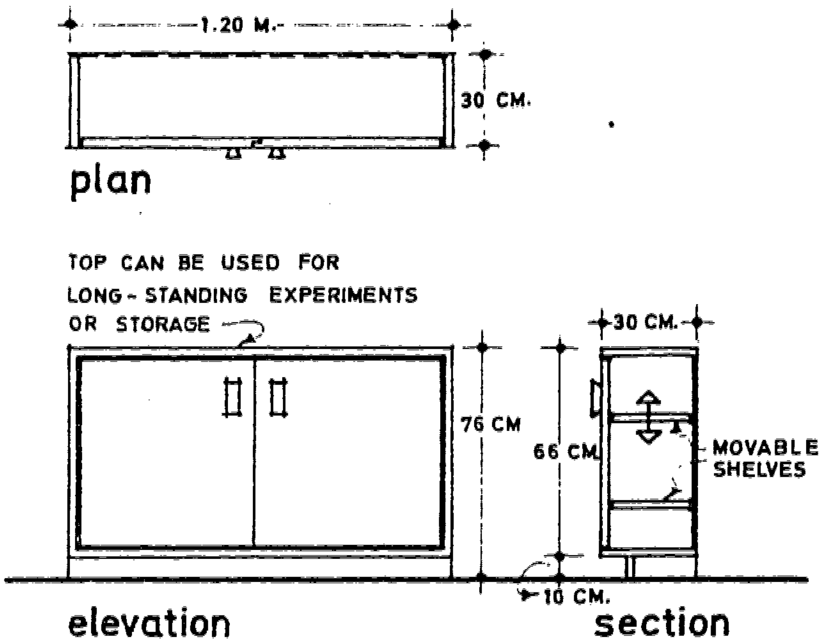
ii) Storage for equipment

Most of the storage for equipments should, it is proposed, be located in the laboratory, where it will be used. On the end wall of the laboratory is a *wall unit* with movable, open shelves, This, because it is open, makes it possible to effectively utilize the storage while, at the same time, items can easily be checked. The top shelf could be used for museum proposes. (Figure 13)



OPEN STORAGE SHELVES

fig. 13



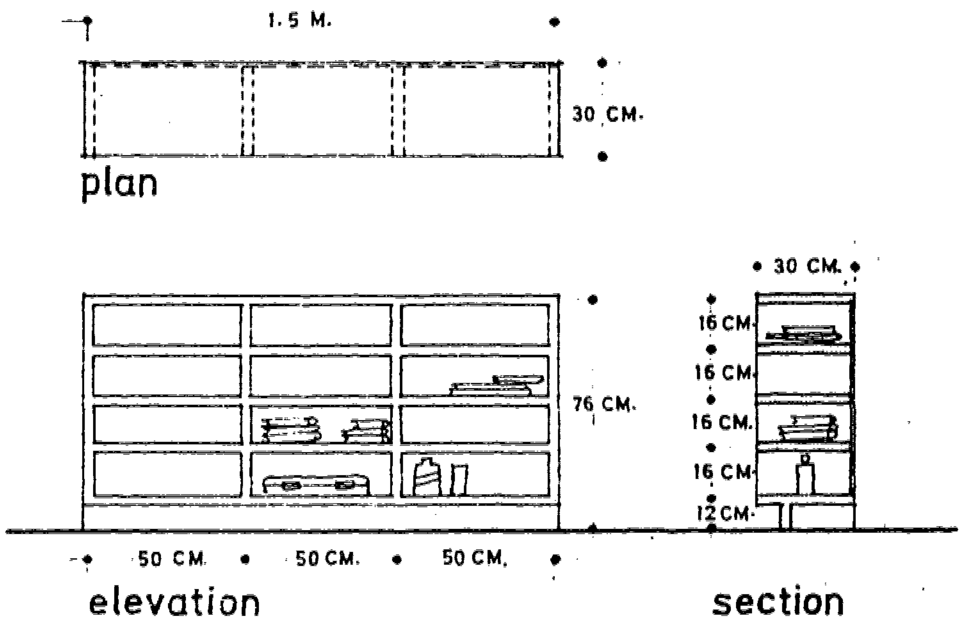
STORAGE WITH DOORS

fig. 14

It might however not be advisable to store some equipment on open shelves (dust, fungus, accessibility). Additional storage with lockable doors is located under the benches at the entrance wall. (Figures 14 and 10)

iii) Students books and bags

As the pupils might bring books and bags which will not be used during the science lesson and which might be a nuisance on the benches, a storage unit for these items is proposed at the entrance to the laboratory (Figures 10 and 15).



BAG AND BOOK STORAGE UNIT

fig. 15

b) Furniture to be moved occasionally

The work table - the design of which has already been discussed and illustrated in Figures 9 and 10 will normally be located at the service units as in Figure 10. It will be shown later however, that on some occasions, a rearrangement could be useful. The table which has no under bench storage, will be easy to move. The table used by the teacher, it is proposed, should be identical to that used by the pupils. A bench height of 76 cm is convenient for an adult for sitting work with a normal chair. For standing work the height is low for some experiments, but for others where the experiment is built up above the table surface the height is more convenient. Furthermore, the top of the service unit is 90cm above floor level which is a convenient "standing height".

c) Often and easily movable furniture

i) The stools, discussed earlier in Part I and measurements of which are given in Figure 1, should be easy to move round as the teaching methods require. For this reason they must be light and the material used should be light metal. A wooden chair might be too heavy but wood is preferred a stool (without backrest) is recommended. An advantage with the backless stool is that it can be completely stored under the bench when not in use.

ii) In addition to the work tables, five smaller *tables on wheels* are proposed (Figure 16). These can be used as additional work surfaces for the students as well as for the teacher. They can also be used for transport of equipment and apparatus, and for experiments prepared before the lesson in the store. Furthermore, they can be used for standing experiments of long duration.

d) Miscellaneous

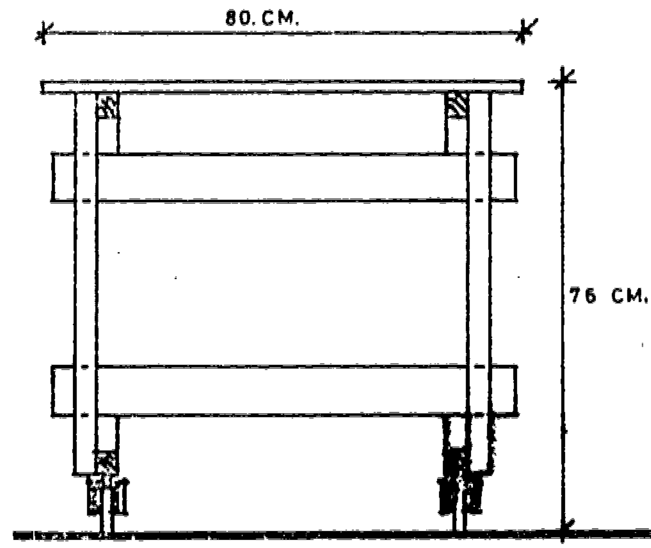
Chalkboard, chart rail - The whole wall length behind the teacher should be used for a chalkboard. Its vertical location should be from about 1.8m above floor level to about 76cm above floor level. It is also useful to paint doors as chalkboards. This extends the possibility of informal lecture and discussions between the teacher and individual or groups. A chart rail should be fixed along the top of the chalkboard.

6. The Physical Implications of the Scheme of Work

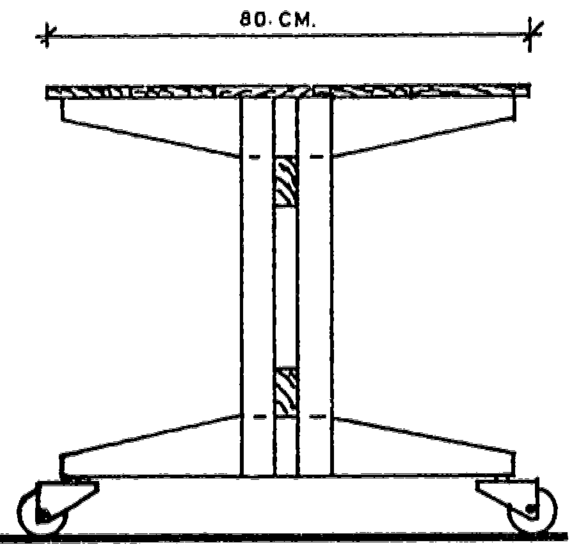
a) Laboratory "A" 89 sq.m. (Figure 10)

The room is divided into two parts, one mainly for demonstrations and one mainly for experiments.

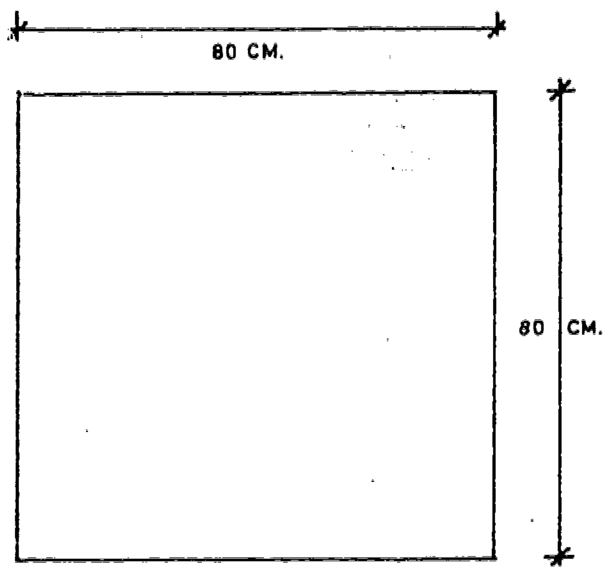
The free area around the demonstration table can easily accommodate 45 students on chairs. This part of the laboratory can be used for demonstrations, lectures and for films or slide projections.



front elevation



side elevation



plan

WORK TABLE
ON WHEELS

fig. 16

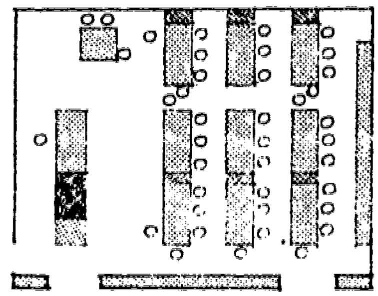
The part of the laboratory set aside for practical work accommodates 36 students with four at each table. To place five at each table is possible but a little less convenient. The laboratory however could then take 45 students. Another way to extend the basic number of 36 students is to locate three of the movable tables (with wheels) in between the basic tables, providing 42 student places.

b) Laboratory "B" 67 sq.m.
(Figure 10)

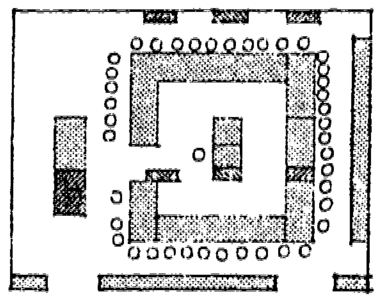
The experimental area in this laboratory is identical with that of laboratory "A" which gives accommodation for up to 45 students. The demonstration area, however, is much smaller. Three ways of accommodating students for demonstrations are suggested:

i) When students need to take notes - The distance from the teacher to the furthest table is short and the students can use the work tables for note taking (see Figure 17).

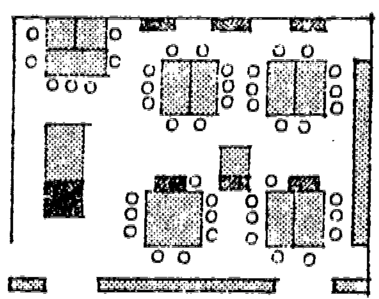
ii) When students need to be close to demonstration to see details - This will be required occasionally and mostly only for short sequences of the demonstrations. At these occasions the students can follow the sequence simply by standing around the demonstration table. It is recommended here in order to avoid overcrowding, to divide the class into parts (20 to 22 pupils each).



a) DEMONSTRATION WITH PUPILS TAKING NOTES AT THE WORK-BENCHES.



b) DISCUSSIONS, DEMONSTRATIONS



c) WORKING IN LARGE GROUPS

ALTERNATIVE FURNITURE ARRANGEMENTS IN SMALLER LABORATORY
fig. 17

50

iii) When the criteria in (i) and (ii) have to be fulfilled at the same time - At these occasions it is suggested to rearrange the furniture as is shown in Figure 17(b). In Figure 17(c) the furniture is arranged for students working in large groups.

e) Some further comments on the Alternative Laboratory Designs

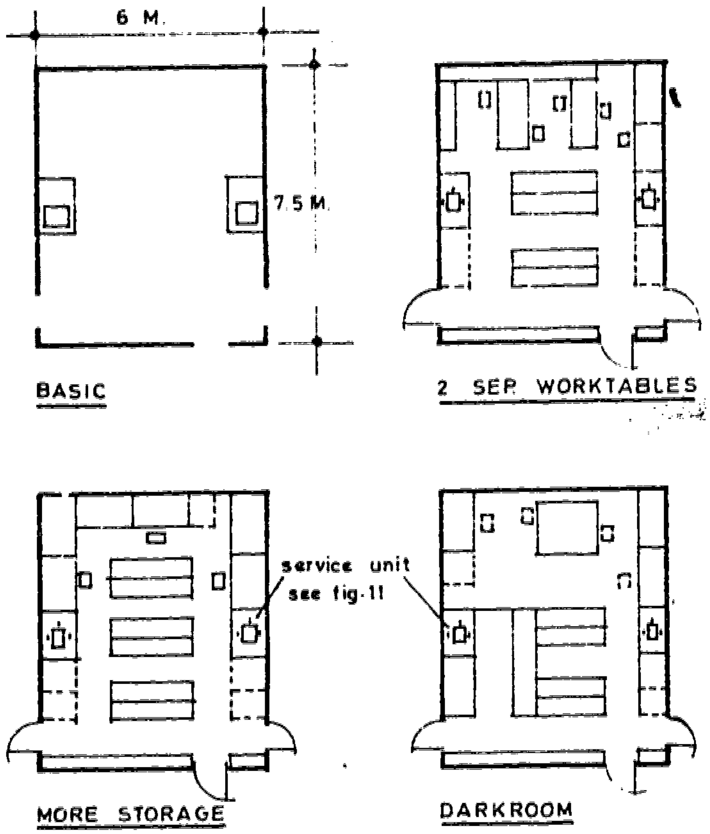
Figure 1) shows one evident advantage of design A, the larger laboratory, over design B. If the method of teaching changes during one period from demonstration to student wor and finally to a recapitulation by the teacher which includes a general discussion, it will be far easier to effect the changes in student positions in the large laboratory. At the end of an experiment, the students laboratory benches will be covered with equipment and thus if there is enough space provided they can take their chairs to the discussion area for the concluding section of the lesson. If there is sufficient money for two sets of chairs or stools, then one set can remain in the experimental area and the other in the discussion area so that all the student have to do is to move from one place to the other.

The second advantage of the larger space provided by the "A" type laboratory is that the demonstration area can also be used, if necessary, for special experiments that require extra space.

The main advantage of the smaller laboratory is, of course, its lower cost. A choice might be made between the larger laboratory without a preparation room or a smaller laboratory with one, in situations where funds are short.

7. Preparation Room

Figure 18 illustrates a simple preparation room. Much of the furniture is similar in design to that proposed for the main laboratory. The furniture should not be fixed in order to preserve the maximum flexibility. A preparation room may serve not only its main purpose which is preparation and storage but also as a temporary dark room, a place for able students to work in, and so on.



A FLEXIBLE PREPARATION-STORAGE ROOM. fig.18

B - A MULTI-PURPOSE LABORATORY FOR LOWER-SECOND LEVEL SCIENCE TEACHING IN CEYLON SCHOOLS

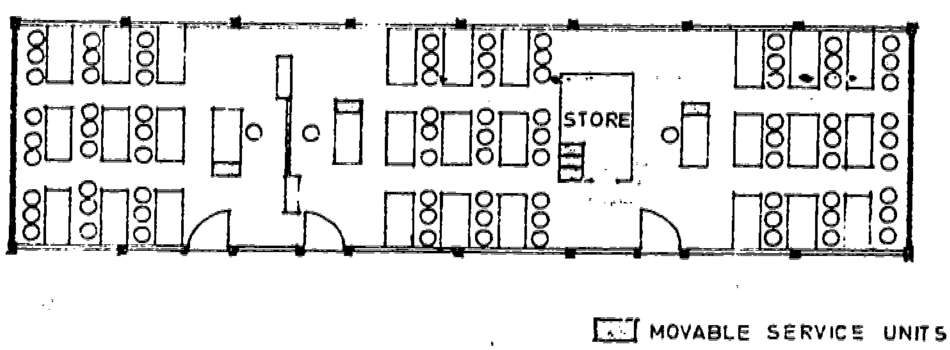
1. Background

The present curriculum for science in Grades IX and X in Ceylon schools is as follows:

	IX	X
PHYSICS	5	6
CHEMISTRY	5	6
BIOLOGY	5	6
	15	18

For each subject and each grade, detailed schemes of work are available in much the same way as they are for the Integrated Science curriculum in Malaysia. Analysis of these schemes shows a substantial proportion of practical work that requires laboratory facilities for its implementation.

Although the Ministry of Education is building new laboratories for schools that do not have any, the overall shortage is such that in many schools it is not possible to give the students more than two periods per week in the laboratories. As a programme of laboratory construction to improve this situation will take many years to carry out, and, as at present a high percentage of science teaching is done in the classroom, it would seem sensible to examine ways in which classrooms can be converted to laboratory use. The Ceylon standard school building fortunately lends itself very well to this approach. The standard school comprises a long, twenty feet wide hall without division between teaching groups as is shown in Figure 19. The children sit in



PLAN OF TYPICAL CEYLON, SINGLE STOREY HALL TYPE BUILDING fig. 19.

normal class groupings and the main difference between this type of building and more conventional schools is that there are no internal division walls between classes.

2: The Solution

The hall-type school is well lit but is not secure as there are no shutters or windows. The open sides in fact provide for thermal comfort. In rural areas, there is rarely piped water, gas or electricity. What is needed is thus a unit from which can be produced at very short notice and somewhat in the manner that a conjurer produces a rabit from a hat, a full laboratory facility. The facility must be such that it can be put back in the "hat" at much the same speed as it was taken out. The unit must be water proof and secure from theft. It will be an added advantage if the unit is easily movable so that, from year to year, its position in the hall can be adjusted depending on the enrolment of students in the classes on either side of it. The solution to the problem is indicated in outline in Figure 20 which also shows how the unit can be located in various positions depending on the sizes.

The general way in which the proposal outlined in Figure 20 operates is as follows: Inside the unit are simple trolleys on which water, plastic sink, spirit lamp and essential equipment as suggested by the frequency of use table are stored. At the start of each science lesson, the teacher unlocks the store and four students take out one trolley each which they locate between a pair of tables. Such other materials as are then needed are also drawn from the locked store and the lesson commences. At the end of the period, the trolleys and materials are wheeled back into the store and the next lesson which might be history or geography commences. Alternatively, the spaces on either side of the store can be reserved for science teaching. Plate V shows a normal class in session for a geography lesson and Plate VI shows the same class, ten minutes later, studying science.

3. Storage Unit

The storage unit will include all items except chairs and worktables, which would normally be kept in the open hall. Some project work, such as the growing of plants, could also be kept in the hall. For the transport of equipment and apparatus between the storage unit and the student's and teather's work stations there are a number of *movable service units* each with the items needed for the lesson. For chemistry lessons, for example, the

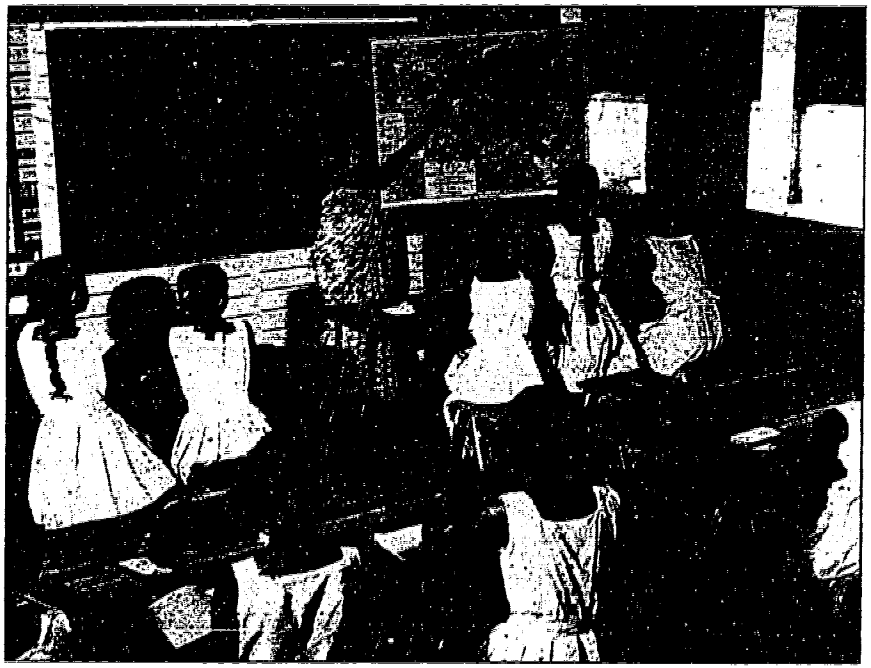


Plate 5 Class studying geography in a Ceylon, hall – type school.

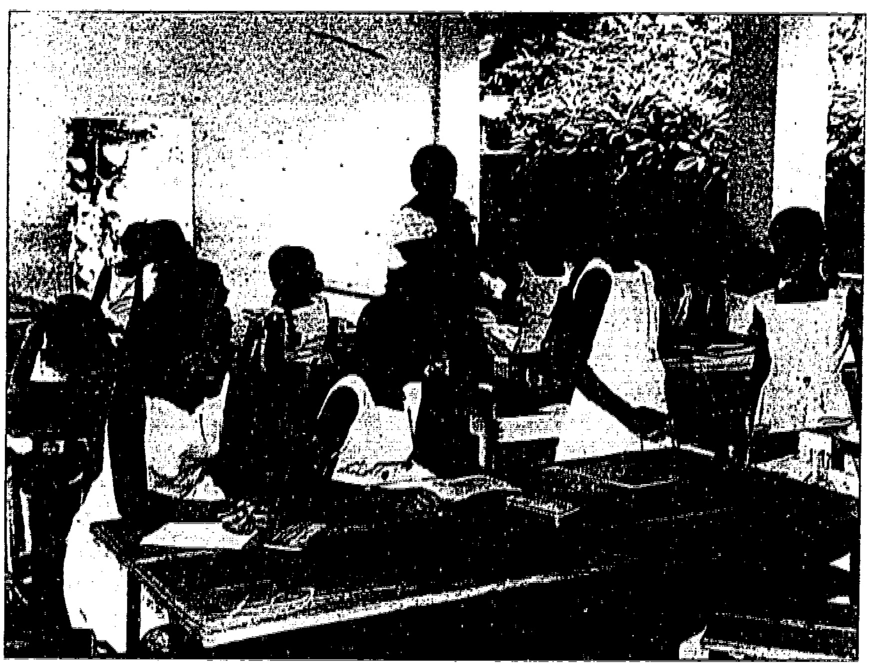


Plate 6 Ten minutes later, the same class studying science in the same space.

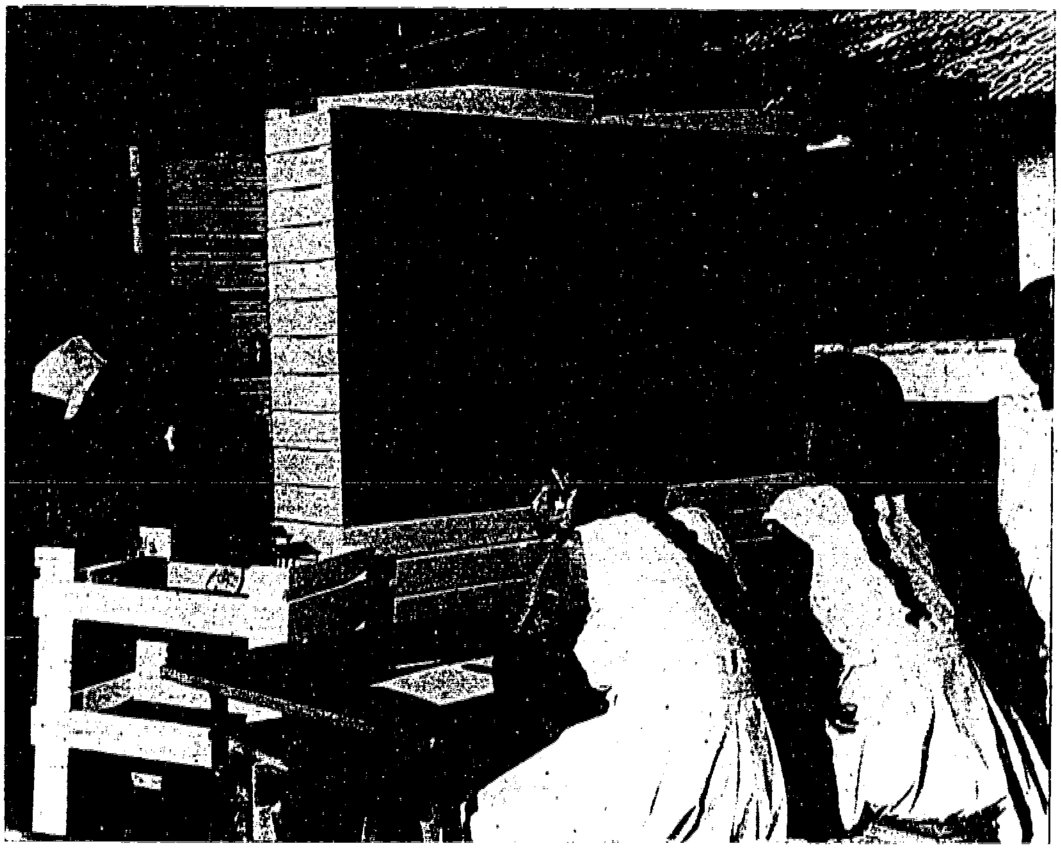
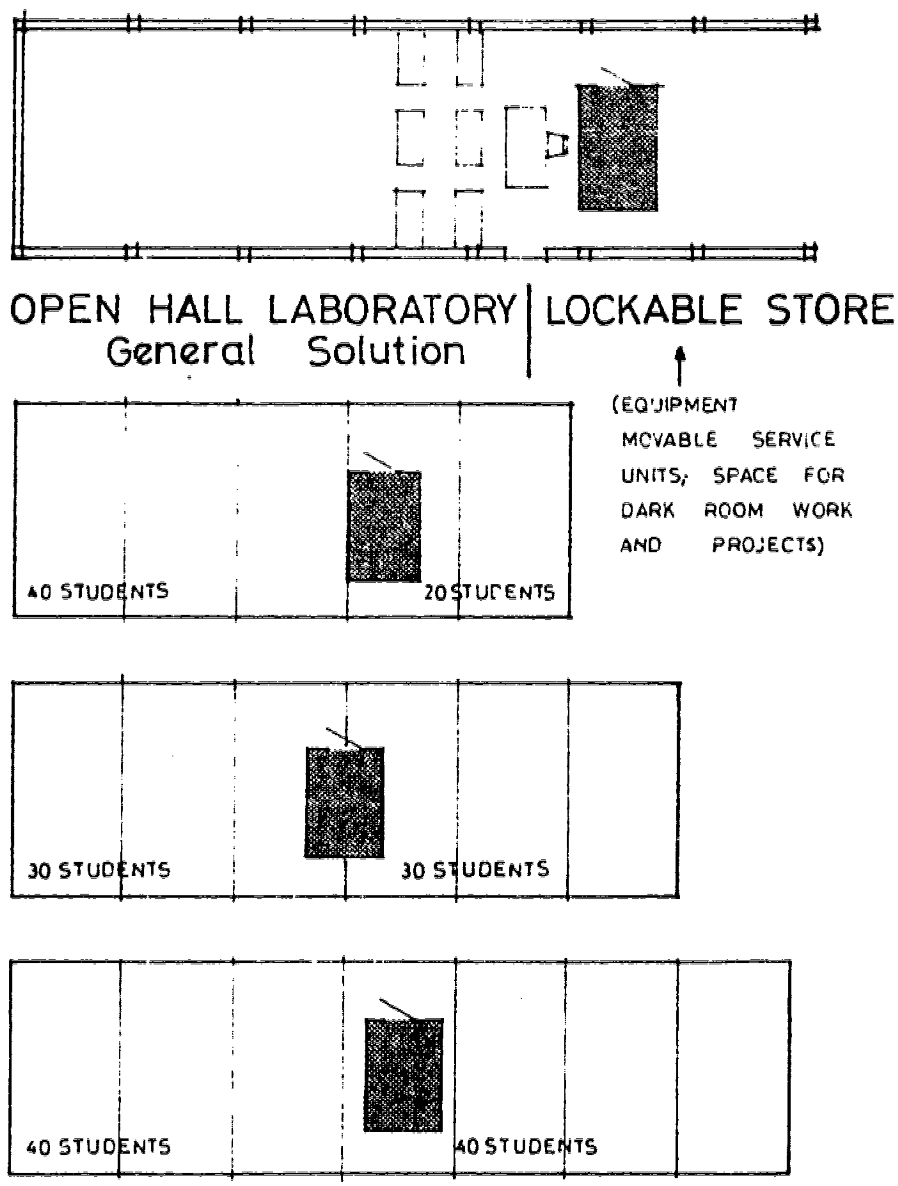


Plate 7 Movable service unit is being taken out of movable storage unit for science lesson.



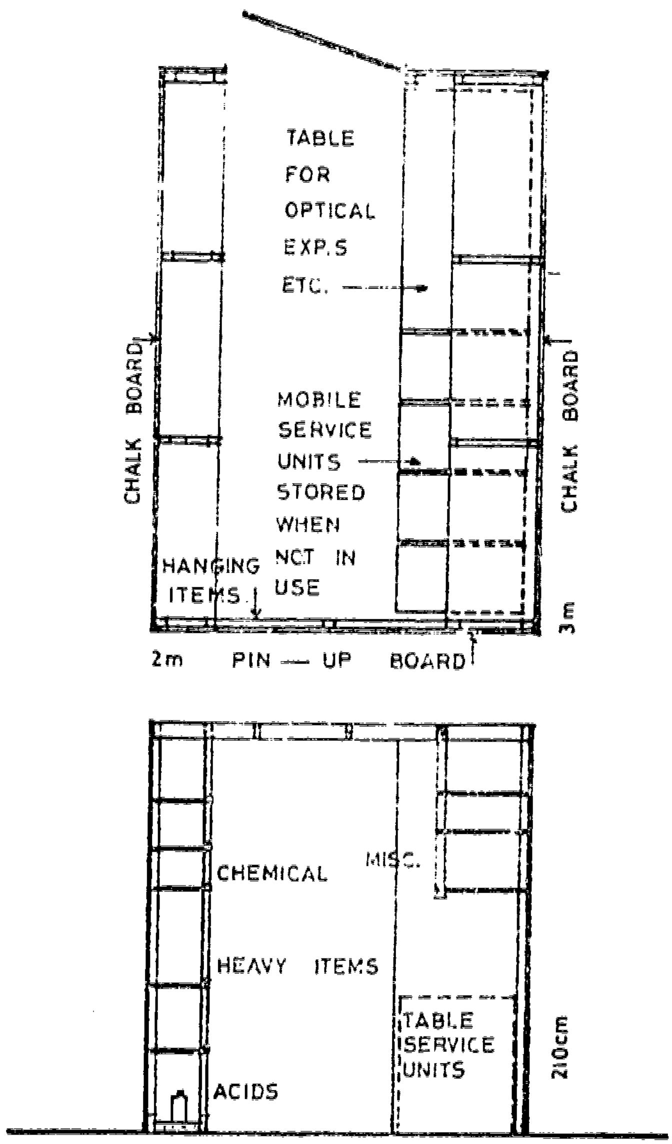
OPEN HALL LABORATORY

Alternative positions of storage Unit depending on class size

fig. 20

units might be loaded with aspirators and sinks, kerosene stoves, beakers, test tubes and chemicals; for a physics lesson they would carry accumulators, electrical fittings, meters etc.

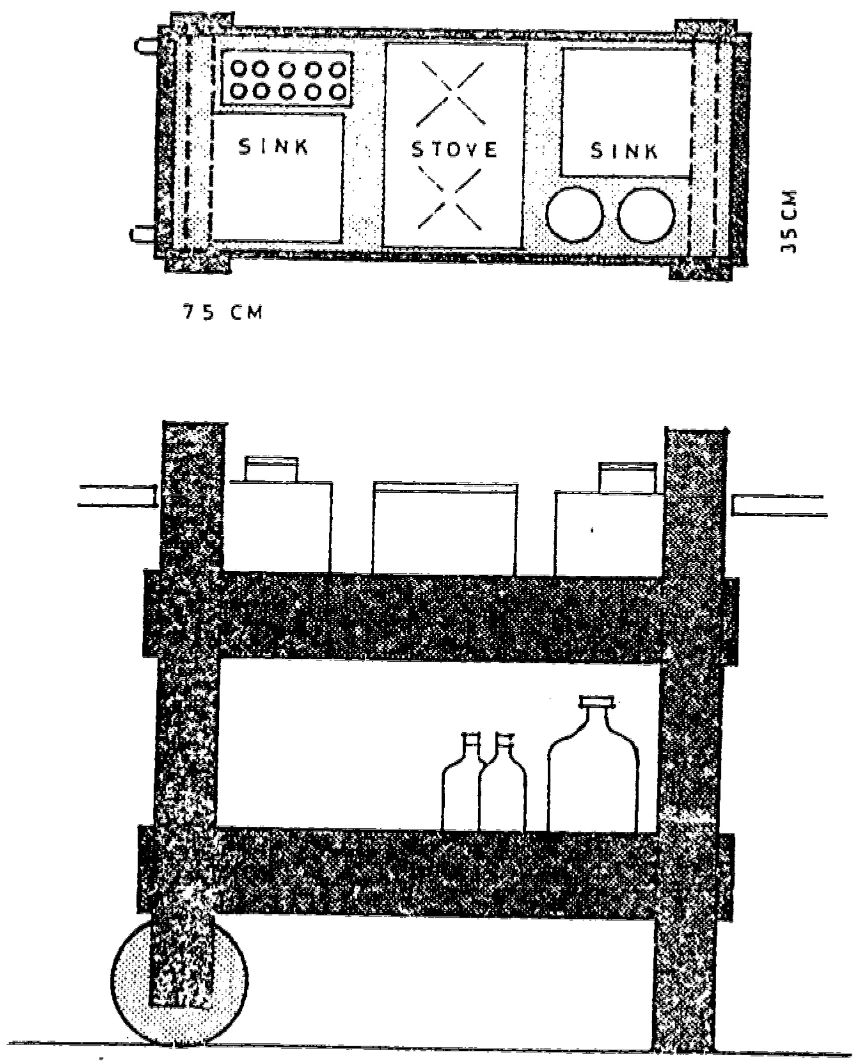
A small number of students could work in the storage unit made into a dark room. This may assist in optical experiments in the physics syllabus. Furthermore, some project work, which needs more than one period to be carried out, could be kept in this storage unit.



STORAGE UNIT

fig. 21

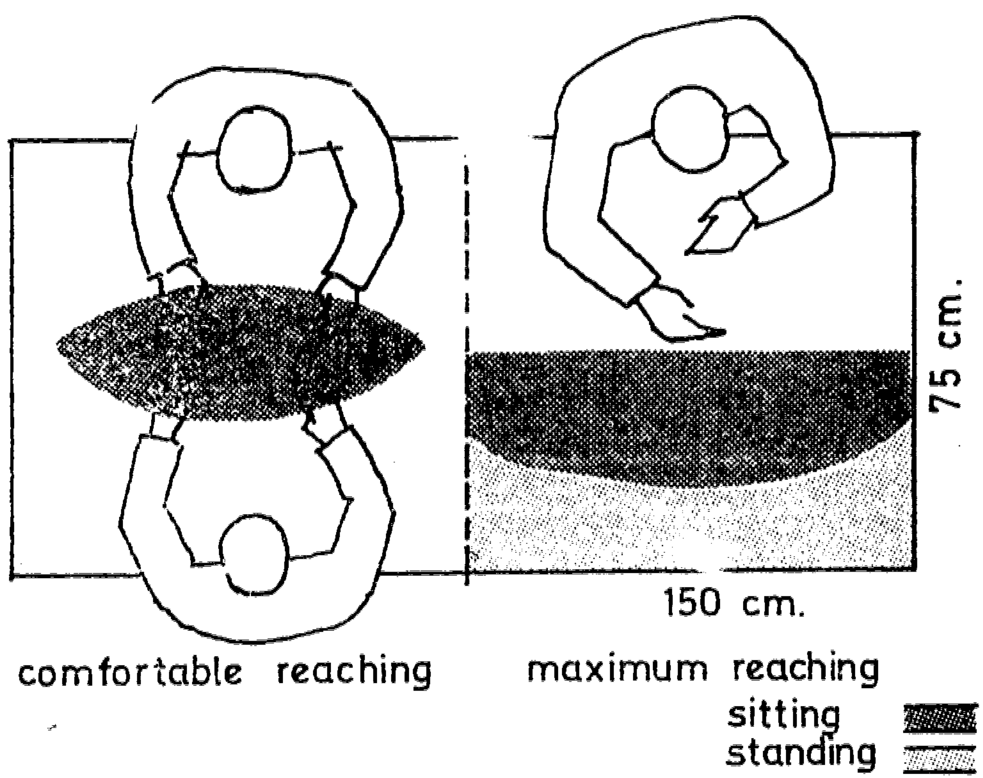
The storage unit is shown in Figure 21 and Plate VII and the movable service unit in Figure 22 and Plate VII.



MOVABLE SERVICE UNIT fig. 22

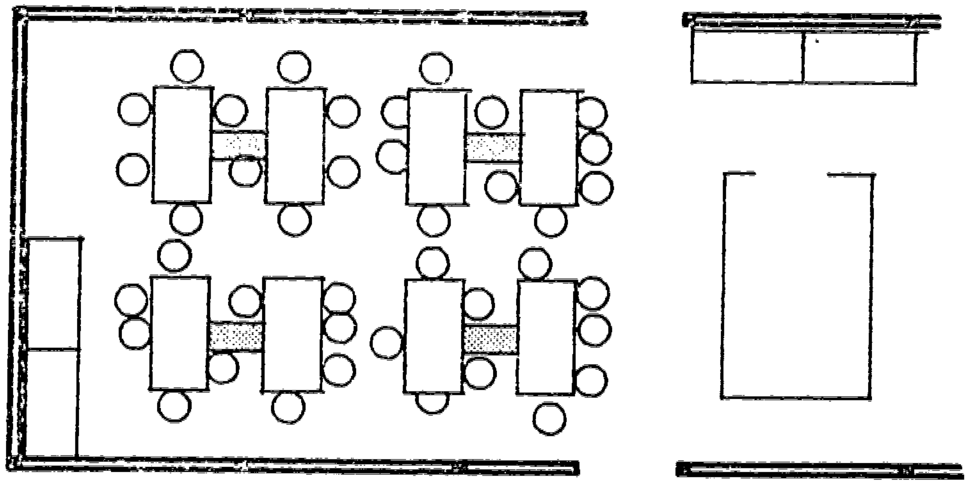
4. The Work Station

The work station will provide convenient working areas for different activities and group sizes. Figure 23 shows how the proposed work top relates to the reaching capacities of the students.

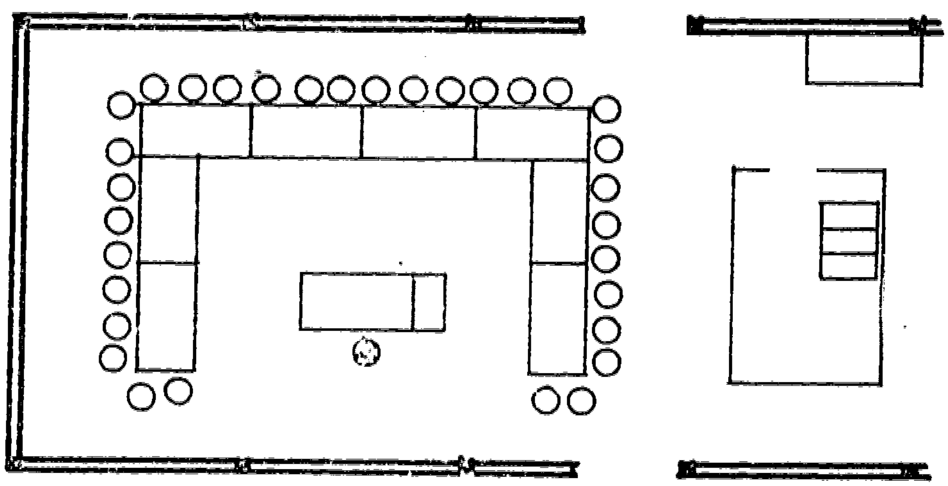


PUPILS REACHING OVER TABLE 75 X 150 cm.
figure. 23

Combinations of this work top in relation to relevant activities is shown in Figures 24A and 24B.

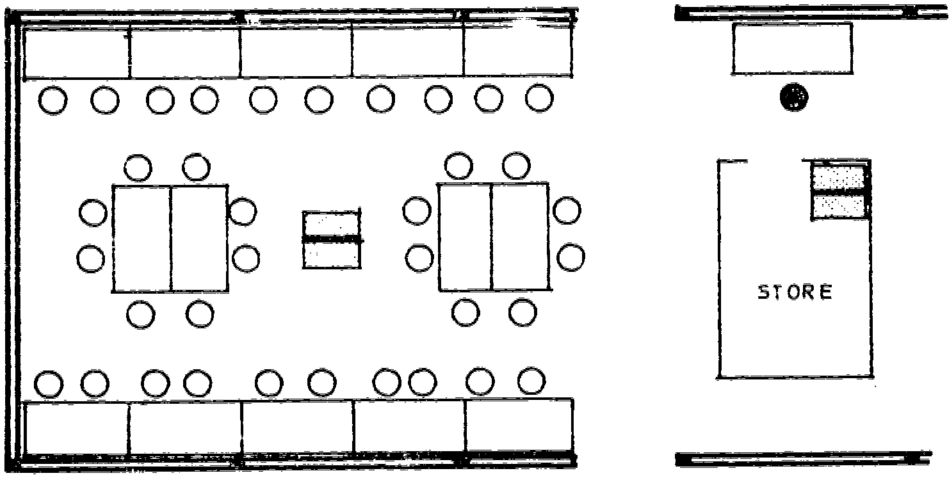


practical work
40 students in groups of 5

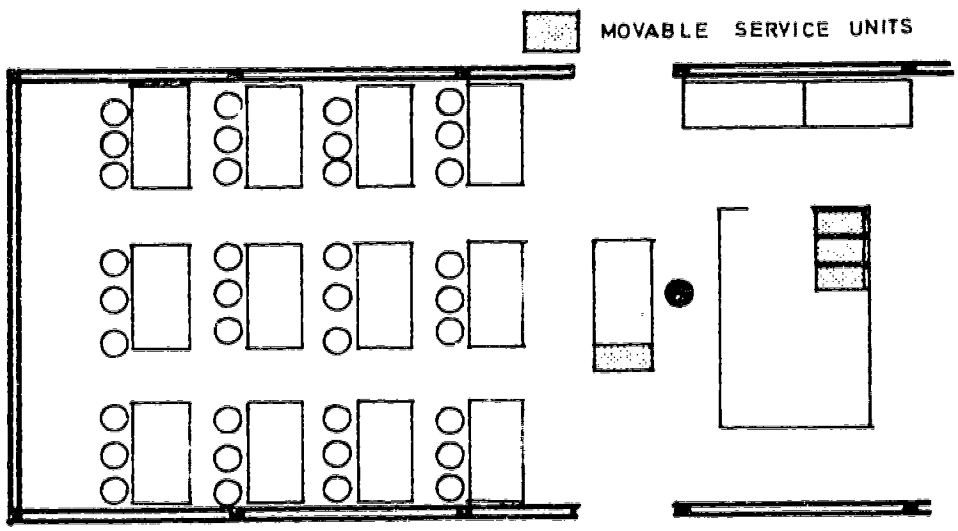


FURNITURE LAY-OUTS FOR DIFFERENT ACTIVITIES fig. 24 A

The work table should be easy to move around, and at the same time, should be rigid. Furthermore, the table should provide adequate knee-space for the pupils (see Figure 1).



microscope work 20 pupils
group work 16 pupils



lectures (demonstrations)
36 pupils

FURNITURE LAY-OUTS FOR DIFFERENT ACTIVITIES fig. 24 B

5. *Conclusion*

Whilst the field trial of the laboratory, described above, for the Malaysian situation will not commence until later in 1970 (although working drawings have already been prepared by the Public Works Department of the Government of Malaysia) the field trial of the science laboratory in the Ceylon situation has now been in progress for three or four months and sufficient confidence in the validity of the design has been established. The Ministry of Education, Ceylon has now decided to install the laboratory in a further hundred Ceylon Secondary Schools by the end of 1970. Opportunity has been taken in studying the Ceylon laboratory in use to make minor modifications to some details of construction, but, by and large, the hundred laboratories yet to be built will substantially follow the original design. The cost of the laboratory and the furniture in the Ceylon situation is approximately one seventeenth of that of the normal conventional laboratory. The unit is, of course, much more flexible. Further reports on the performance of the designs described in both of the case studies above will be published, from time to time, by the Institute in its periodical "Technical Notes".