

SPACE UTILISATION
AND THE REDUCTION OF SCHOOL BUILDING COSTS

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Rapid educational expansion is urgently needed in many countries. But the resources available to provide such expansion are severely limited, and costs are rising. As a result, a great deal of attention is being given to capital investment in education.

Among the many factors that affect capital costs, the aspect of space utilisation is one that deserves special mention. Not only is it related to reducing costs but the improvement of such utilisation can open the way for providing better solutions to school planning problems and make available funds for the improvement of the teaching environment.

In Africa enrolment at the first level of education rose from 8,511,000 in 1950 to 28,028,000 in 1967. In Asia the corresponding figures are 53,303,000 and 126,080,000 respectively.

World statistics for the three levels of education show that such expansion does not only apply to developing countries but also to developed ones and as such the problem is universal. However, in developing countries the problems faced are particularly acute since, in spite of the fact that the percentage of public expenditure being put into education is growing year by year, a large percentage of school age children cannot be accommodated.

The examples which are quoted are first hand experiences of the author in Africa and they demonstrate how the aspect of space utilisation can contribute substantially towards reducing the capital cost per pupil.

Recent surveys have shown that the traditional method of providing a general classroom as a permanent station for a class results in a low rate of use of the general classroom spaces provided because when pupils are in laboratories, library, gymnasium, etc. the general classrooms remain empty. It has also been shown that enrolment as a factor affecting the use of specialised spaces (which are the most costly) is not receiving the attention it deserves.

Room and student station utilisation

Educational spaces should be considered in three dimensions, namely:-

- a) the number and category of spaces provided
- b) the time during which these spaces are available
- c) the student stations which such spaces provide.

Thus it can easily be seen that for an intensive utilisation the rate of occupancy for both rooms and student stations must be raised to the

TABLE I

SUMMARY OF UTILIZATION DATA BY KINDS OF INSTRUCTIONAL ROOMS ON A WEEKLY BASIS

Weekly periods : 44

Room Category		Code:CG						
Room identification		Room utilization weekly basis			Student-station utilization weekly basis			
Block Number	Room Number	Weekly Class periods	Weekly Room periods	Percentage utilization	No. of student stations	Possible student station periods	Student Station periods used C.A	Percentage utilization
1	2	3	4	5	6	7	8	9
Block A	1/A	28	44	63.6	40	1760	1120	63.6
	2/A	32	44	72.7	40	1760	1280	72.7
	3/A	30	44	68.2	40	1760	1200	68.2
	4/A	30	44	68.2	40	1760	1200	68.2
Block B	1/B	28	44	63.6	40	1760	1120	63.6
	2/B	28	44	63.6	40	1760	1120	63.6
	3/B	28	44	63.6	40	1760	1120	63.6
	4/B	28	44	63.6	40	1760	1120	63.6
Block C	1/C	27	44	61.4	40	1760	1080	61.4
	2/C	28	44	63.6	40	1760	1120	63.6
	3/C	28	44	63.6	40	1760	1120	63.6
	4/C	28	44	63.6	40	1760	1120	63.6
Block D	1/D	28	44	63.6	40	1760	1120	63.6
	2/D	28	44	63.6	40	1760	1120	63.6
	3/D	28	44	63.6	40	1760	1120	63.6
	4/D	28	44	63.6	40	1760	1120	63.6
Ass. Hall	1/E	32	44	72.7	40	1760	1280	72.7
Block	2/E	30	44	68.2	40	1760	1200	68.2
Masters house	1/F	28	44	63.6	40	1760	1120	63.6
"	2/F	28	44	63.6	40	1760	1120	63.6
Total	R = 20	C = 573			A = 800			

R = Total number of rooms (a count of the rooms of col. 2).

Total available room periods per week = N.R

= 44. R =

C max = 880

Total available student-station periods per week = N.ΣA

= 44.ΣA =

B max = 35200

highest possible allowed.

Computation technique

Table I gives data collected with respect to the actual utilisation of the general classroom category in a school which has twenty classrooms available for forty-four periods a week each and each accommodating 40 student stations.

Thus if N is the number of periods/week during which a room is available and C is the actual number of periods during which the classroom is used, and if U is the percentage utilisation, then:-

$$U = \frac{C}{N} \times 100$$

and for room 1 in Block A:-

$$U = \frac{28}{44} \times 100 = 63.6\%$$

Also if A is the number of student stations in the class, and B is the number of student station periods available, then:-

$$B = N \times A = 44 \times 40 = 1760$$

If U_s is the percentage utilisation of the student station periods, then:-

$$U_s = \frac{28 \times 40}{44 \times 40} = 63.6\%$$

It is to be noted that it is assumed here that all the stations are used and thus we have the same percentage utilisation for both the student station and the room. However, if classes are to be taken in smaller groups and some of these student stations remain unused, then a corresponding drop in the student station utilisation will occur. Thus for this room if only 20 student stations are occupied during 15 periods of the total of the 28 during which the class is used, then:-

$$U_s = \frac{(13 \times 40) + (15 \times 20)}{44 \times 40} = 46.6\%$$

From this it can be seen that care should be given to making intensive use of the student stations through the provision of variously sized teaching spaces which will provide for various teaching situations. This can be achieved through mobile partitions, seminar rooms, etc.

It should further be pointed out that the analysis on Table I shows a rather low percentage utilisation for the general classroom category which can efficiently be used up to a maximum of 90%. Such low usage is attributed to the fact that the use of those rooms which have been assigned as permanent bases to each grade leaves them empty when these grades are being instructed in specialised areas such as science labs, etc. As such, if any intensive use is to be achieved, then lockers should be provided and the use of these rooms by the whole school population should be considered.

It can be seen that with 20 classrooms the number of periods during which these classes are available is $20 \times 44 = 880$, out of which only 573 are being used, giving an average utilisation for the whole general

classroom category of:-

$$\text{Uav. var.} = \frac{573}{880} = 65.1\%$$

The number of rooms actually required can be seen to be:-

$$\frac{573}{44} = 14 \text{ rooms}$$

allowing 43 periods in excess during which classes will remain empty, thus allowing a margin of flexibility to cater for timetabling difficulties.

Impact of enrolment on utilisation

In one of the African countries an investigation was made of their secondary schools with a view to determining the optimum enrolment that would secure a maximum utilisation. The following is a summary of findings for the boys' secondary schools.

Subject load table for a boys' academic secondary school

The weekly subject load was as given in the following table.

TABLE II

Subject	1st grade	2nd grade	3rd grade	4th grade
Arabic	6	6	6	6
English	9	9	9	8
Science	6	6	6	6
Mathematics	6	6	6	6
Geography	3	3	4	4
History	3	3	3	4
Religion	3	3	3	3
Art	4	4	3	3
Physical Education	2	2	2	2

Determination of optimum enrolment

To arrive at the optimum enrolment, the following facts were taken into consideration:-

- a) that a stream is made up of four classes with forty pupils per class;
- b) that subjects are under the responsibility of specialised departments namely:-

The Arabic department for Arabic and Religious subjects

The English department for English language and English literature

The Mathematics department

The History & Geography department

The Science department

The Arts department

The Physical Education department

- c) that Arabic, Religious subjects, English language, English literature, Mathematics and History are taught in general classrooms (CG);
- d) that Geography and Arts & Crafts are taken in special classrooms (CS);
- e) that Physics, Chemistry and Biology are taken in Science laboratories (SL);
- f) that the English and Arabic library periods are taken in the library;
- g) that Physical Education is given in the open air.

Table III gives the number of periods taught by various Departments calculated for schools with an enrolment of from one to six streams.

Practicable room utilisation values

To allow flexibility in timetabling and for the preparation and setting up of experiments and demonstrations, the following values were taken:

Room designation	u_{pr} (%)	$f = \frac{1}{u_{pr}}$
General classrooms	90	1.11
-----	-----	-----
Geography room	100	1.00
-----	-----	-----
Art room	100	1.00
-----	-----	-----
Science labs.	85.7	1.17
-----	-----	-----
Library	100	1.00

Thus the minimum number of rooms is calculated as follows:-

$$R \geq f \cdot \frac{\sum Pr}{42} = f \frac{\text{Sum of periods per room category}}{\text{No. of periods during which the room is available}}$$

The average periods per room are:-

$$P_r = \frac{\sum Pr}{R}$$

TABLE III

SUBJECT LOAD TABLE FOR BOYS' ACADEMIC SECONDARY SCHOOLS WITH DIFFERENT NUMBERS OF STREAMS

1 stream: 4 classes, 40 pupils per class, design enrolment 4 . 40 = 160 pupils.

Room category	Subject	Department	Periods per grade				Periods per school											
			1.	2.	3.	4.	1 stream 4 classes 160 pupils	2 streams 8 classes 320 pupils	3 streams 12 classes 480 pupils	4 streams 16 classes 640 pupils	5 streams 20 classes 800 pupils	6 streams 24 classes 960 pupils						
CG	Arabic	Arabic & Religion	6 ⁺	6 ⁺	6 ⁺	6 ⁺	24	48	72	96	120	144	180	216				
	Religion	Dpt.	3	3	3	3	12	24	36	48	60	72	84	96				
	English	English Dpt.	6 ⁺	6 ⁺	6 ⁺	5 ⁺	23	46	69	92	115	138	175	210				
	Engl. Literature		3	3	3	3	12	24	36	48	60	72	84	96				
CS	Mathematics	Mathematics Dpt.	6	6	6	6	24	48	72	96	120	144	180	216				
	History	Hist. & Geogr. Dpt.	3	3	3	4	13 ^x	26 ^x	39 ^x	52 ^x	65 ^x	78 ^x	91 ^x	104 ^x				
	E Periods		27	27	27	27	108	216	324	432	540	648	756	864				
	Geography	Hist. & Geogr. Dpt.	3	3	4	4	14 ^x	28 ^x	42 ^x	56 ^x	70 ^x	84 ^x	98 ^x	112 ^x				
SL	Arts & Crafts	Arts & Crafts Dpt.	4	4	3	3	14	28	42	56	70	84	98	112				
	Physics	Science Dpt.	2	2	2	2	8	16	24	32	40	48	56	64				
	Chemistry		2	2	2	2	8	16	24	32	40	48	56	64				
	Biology		2	2	2	2	8	16	24	32	40	48	56	64				
—	E Periods		6	6	6	6	24	48	72	96	120	144	168	192				
	Phys. Education	Phys. Ed. Dpt.	2	2	2	2	8	16	24	32	40	48	56	64				
	EE Periods		42	42	42	42	168	336	504	672	840	1008	1176	1344				

[†]) 1 library period included

^x) The values in the same columns have to be added to obtain the periods per History & Geography Department.

The percentage of possible room periods is:-

$$U = \frac{P_r + 100}{R + 42} = \frac{\text{Sum of periods per room category} \times 100}{\text{Number of rooms} \times \text{Number of periods per week}}$$

Tables IV to IX show calculations for schools with enrolments ranging from one to six streams.

Graphs I to VI have been prepared for easy comparison of the data contained in these tables.

ROOM REQUIREMENTS OF BOYS' ACADEMIC SECONDARY SCHOOLS

Table IV

No. of streams of school : One Enrolment acc. to design : Ai = 160

ROOM REQUIREMENTS						
Room	Periods per room-category	Flexibility factor	Min. No. of rooms required	Average periods per room	Percent. of poss. room periods	Pupil/room ratio
	$\sum P$	$f = b \frac{1}{u_{pr}}$	$R = f \cdot \frac{\sum P}{42}$	$p = \frac{\sum P}{R}$	$u = \frac{\sum P \cdot 100}{R \cdot 42}$	$\frac{\sum Ai}{R}$
0	1	2	3	4	5	6
GEN. CLASSR.	100	1.11	3	33.3	79.29	33.3
GEOGRAPHY ROOM	14	1.00	1	14.0	33.33	160.0
ART ROOM	14	1.00	1	14.0	33.33	160.0
SCIENCE LABS	24	1.17	1	24.0	57.14	160.0
LIBRARY	8	1.00	1	8.0	19.05	160.0
TOTAL	160	-	7	22.9	54.52	22.9

Table V

No. of streams of school : Two Enrolment acc. to design : Ai = 320

ROOM REQUIREMENTS						
Room	Periods per room-category	Flexibility factor	Min. No. of rooms required	Average periods per room	Percent. of poss. room periods	Pupil/room ratio
	$\sum P$	$f = b \frac{1}{u_{pr}}$	$R = f \cdot \frac{\sum P}{42}$	$p = \frac{\sum P}{R}$	$u = \frac{\sum P \cdot 100}{R \cdot 42}$	$\frac{\sum Ai}{R}$
0	1	2	3	4	5	6
GEN. CLASSR.	200	1.11	6	33.3	79.29	53.3
GEOGRAPHY ROOM	28	1.00	1	28.0	66.67	320.0
ART ROOM	28	1.00	1	28.0	66.67	320.0
SCIENCE LABS	48	1.17	2	24.0	57.14	160.0
LIBRARY	16	1.00	1	16.0	38.10	320.0
TOTAL	320	-	11	29.1	69.29	29.1

ROOM REQUIREMENTS OF BOYS' ACADEMIC SECONDARY SCHOOLS

Table VI

No. of streams of school : Three

Enrolment acc. to design : Ai = 480

ROOM REQUIREMENTS						
Room	Periods per room category $\sum P$	Flexibility factor $f = b \frac{1}{u_{pr}}$	Min. No. of rooms required $R = f \cdot \frac{\sum P}{42}$	Average periods per room $p = \frac{\sum P}{R}$	Percent. of poss. room periods $u = \frac{\sum P \cdot 100}{R \cdot 42}$	Pupil/room ratio $\frac{\sum A_i}{R}$
0	1	2	3	4	5	6
GEN. CLASSR.	300	1.11	8	37.5	89.29	60.0
GEOGRAPHY ROOM	42	1.00	1	42.0	100	480.0
ART ROOM	42	1.00	1	42.0	100	480.0
SCIENCE LABS	72	1.17	2	36.0	85.72	240.0
LIBRARY	24	1.00	1	24.0	57.14	480.0
TOTAL	480	-	13	36.9	87.86	36.9

Table VII

No. of streams of school : Four

Enrolment acc. to design : Ai = 640

ROOM REQUIREMENTS						
Room	Periods per room-category $\sum P$	Flexibility factor $f = b \frac{1}{u_{pr}}$	Min. No. of rooms required $R = f \cdot \frac{\sum P}{42}$	Average periods per room $p = \frac{\sum P}{R}$	Percent. of poss. room periods $u = \frac{\sum P \cdot 100}{R \cdot 42}$	Pupil/room ratio $\frac{\sum A_i}{R}$
0	1	2	3	4	5	6
GEN CLASSR.	400	1.11	11	36.4	86.67	58.1
GEOGRAPHY ROOM	56	1.00	2	28.0	66.67	320.0
ART ROOM	56	1.00	2	28.0	66.67	320.0
SCIENCE LABS	96	1.17	3	32.0	76.19	213.0
LIBRARY	32	1.00	1	32.0	76.19	640.0
TOTAL	640	-	19	33.7	80.24	33.7

ROOM REQUIREMENTS OF BOYS' ACADEMIC SECONDARY SCHOOLS

Table VIII

No. of streams of school : Five Enrolment acc. to design : Ai = 800

ROOM REQUIREMENTS						
Room	Periods per room category $\sum P$	Flexibility factor $f = b \frac{1}{u_{pr}}$	Min. No. of rooms required $R = f \cdot \frac{\sum P}{Z}$	Average periods per room $P = \frac{\sum P}{R}$	Percent. of poss. room periods $u = \frac{\sum P \cdot 100}{R \cdot Z}$	Pupil/room ratio $\frac{\sum Ai}{R}$
0	1	2	3	4	5	6
GEN. CLASSR.	500	1.11	14	35.7	85.00	57.1
GEOGRAPHY ROOM	70	1.00	2	35.0	83.33	400.0
ART ROOM	70	1.00	2	35.0	83.33	400.0
SCIENCE LABS	120	1.17	4	30.0	71.43	200.0
LIBRARY	40	1.00	1	40.0	95.24	800.0
TOTAL	800	-	23	34.8	82.85	34.8

Table IX

No. of streams of school : Four Enrolment acc. to design : Ai = 960

ROOM REQUIREMENTS						
Room	Periods per room category $\sum P$	Flexibility factor $f = b \frac{1}{u_{pr}}$	Min. No. of rooms required $R = f \cdot \frac{\sum P}{Z}$	Average periods per room $P = \frac{\sum P}{R}$	Percent. of poss. room periods $u = \frac{\sum P \cdot 100}{R \cdot Z}$	Pupil/room ratio $\frac{\sum Ai}{R}$
0	1	2	3	4	5	6
GEN. CLASSR.	606*	1.11	16	37.9	90.18	60.0
GEOGRAPHY ROOM	84	1.00	2	42.0	100.0	480.0
ART ROOM	84	1.00	2	42.0	100.0	480.0
SCIENCE LABS	144	1.17	4	36.0	85.72	240.0
LIBRARY	42*	1.00	1	42.0	100	960.0
TOTAL	960	-	25	38.4	91.43	38.4

* It has been assumed in this case that the pupils of the first grade shall have one library period (Arabic or English) in their classrooms. This is feasible with regard to the classroom time-table. Therefore, the periods in the relevant room-categories are as follows:-

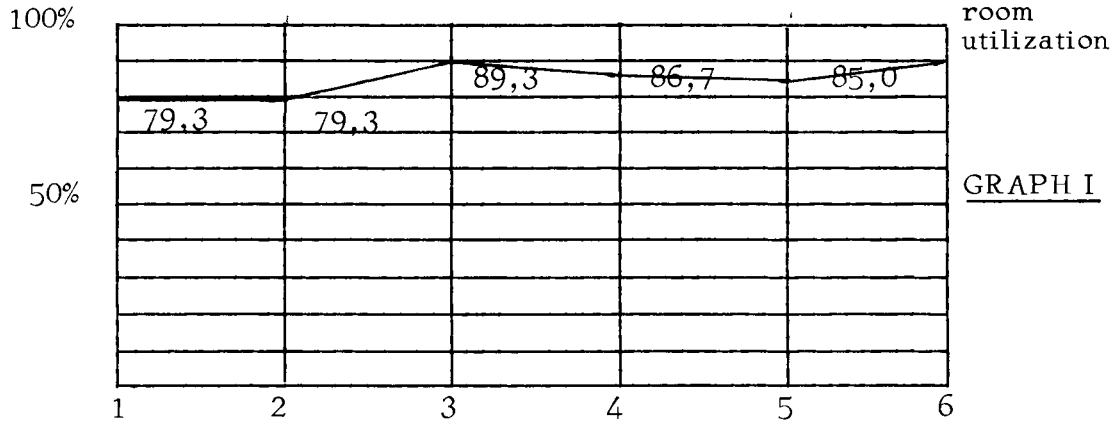
General classrooms 600 + 6 = 606
Library 48 - 6 = 42

BOYS' ACADEMIC SECONDARY SCHOOLS

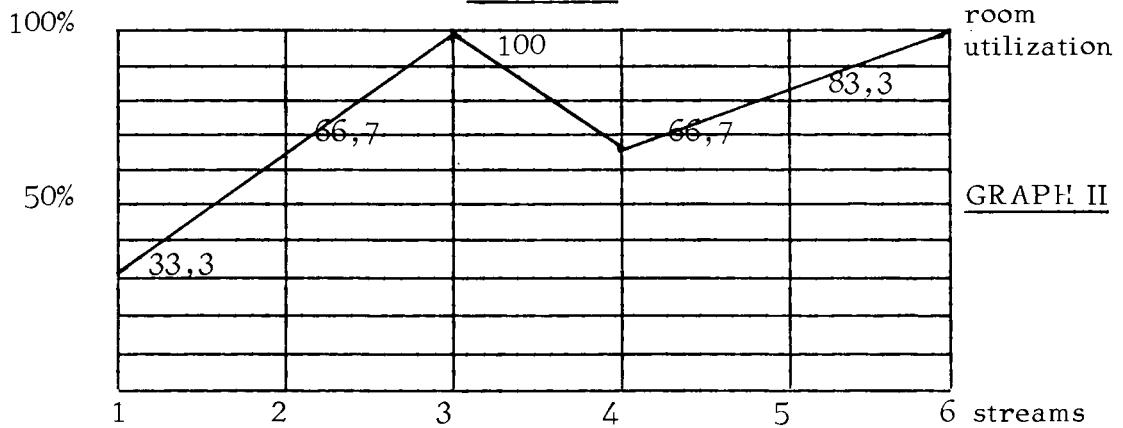
ROOM UTILIZATION AS FUNCTION OF THE ENROLMENT OF A SCHOOL

(100% = 42 room periods per week)

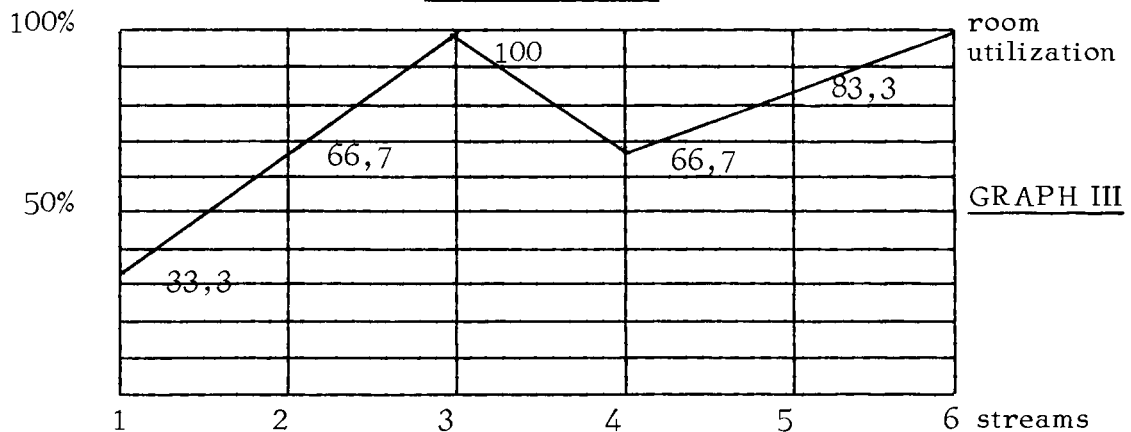
General classrooms



Arts room



Geography room



BOYS' ACADEMIC SECONDARY SCHOOLS

ROOM UTILIZATION AS FUNCTION OF THE ENROLMENT OF A SCHOOL

(100% = 42 room periods per week)

