Infrastructure Choices in Education: Location, Build or Repair

ABSTRACT

The purpose of this study is to develop a model to arrive at a joint optimizing strategy for the use of a given capital budget for the construction of new school buildings and for the repair of the already existing schools. This is to be done in a way that will have the maximum positive impact on the enhancement of the education system. Cost effectiveness analysis is used as the main analytical tool in the analysis. A key factor of the model is that it gives one the optimal mix of repair versus new construction that should be undertaken under a fixed budget constraint. The model is simulated using a sample data set from the information available for the education sector of Limpopo Province, South Africa. It utilizes a very basic set of information that is available in all school districts across the province. Application of this model for the selection of infrastructure investments (either building or repair) in the education sector would increase the efficiency of capital expenditure in this sector. This is particularly the case for the countries that are faced with a large excess demand for school buildings.

JEL codes: D61, I28, H52, H75

Key Words: education, cost effectiveness, school location, school construction, school repair, South Africa

INFRASTRUCTURE CHOICES IN EDUCATION: LOCATION, BUILD OR REPAIR

By

Armin Zeinali

Department of Economics, Queen's University, Canada

Glenn P. Jenkins

Department of Economics, Queen's University, Canada and

Eastern Mediterranean University, North Cyprus

Andrey Klevchuk

Cambridge Resources International Inc.

April 2009

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INTRODUCTION

The education sector in many developing countries suffers from lack of school buildings and other infrastructure. Classrooms are not adequate for the large population of students and often the classrooms are in very poor condition. Over time without renovation many will become unusable. In addition, when there is a rapidly growing population the situation becomes progressively worse over time. To alleviate the problem some developing countries (such as South Africa) are investing substantial amounts of funds in school construction and maintenance. As there is often a limited amount of funds available for such public sector investments, or a limited capacity to erect such structures, it is important to have a system and a criterion to allocate the budget efficiently.

The inefficiency of educational spending has been discussed in the literature by many scholars. It appears that seldom is the budget for education allocated in a highly efficient manner (Levin 2001). Using cost effectiveness analysis this study tries to develop a model for prioritization of infrastructure investments in education. The objective is to find the most efficient strategy for construction and renovation of educational infrastructure where the education system suffers from a severe shortage of school spaces and there are either funding or implementation constraints.

Cost-effectiveness ratios are just estimated for each of the alternatives and the ratios are compared so that the most efficient options are chosen (Jenkins and Klevchuk, 2004). In order to make an evaluation of alternatives that their cost or benefits are spread over time, the costs and the quantity of the effectiveness measure must be discounted up to the present time. To calculate the cost effectiveness (CE) ratio the present value of costs is divided by the present value of the effectiveness,

$$CE = \frac{PV(Costs)}{PV(Effectiveness)} \quad . \qquad (1)$$

Cost and effectiveness in most situations should be measured incrementally (Boardman, Greenberg, Vining, and Weimer, 2001). For example, if we have two alternative policies labeled *i* and *j*. The cost effectiveness ratio CE_{ij} of alternative *i* relative to the alternative *j*, can be estimated as,

$$CE_{ij} = \frac{C_i - C_j}{E_i - E_j} \quad . \qquad (2)$$

Where Cost and effectiveness of alternatives *i* and *j* are denoted respectively by C_i and C_j, and the effectiveness of the alternatives *i* and *j* are respectively denoted by E_i and E_j.

In many developing countries in Africa, the shortage of physical classroom space is a serious problem at the primary and secondary school level. For example, in the Limpopo province of South Africa, the critical problem is the serious shortage of classrooms in which the learners can be taught. In this case the constraint is the capacity of the provincial government to implement more than a certain amount of school construction in a year. Significant funds have been allocated to infrastructure investments in the Limpopo province. Due to political pressures, however, a large share of those investments has been allocated to school districts that are not in serious need. The Department of Education did not have an objective basis for selecting the school areas that are in greatest need for additional school buildings. [1]

The purpose of this study is to develop a model to rank the construction and renovation investments in education according to their effect on the effectiveness of the education system.

Defining the effectiveness measure

To carry out a cost effectiveness analysis a measure of effectiveness of investments should first be defined. Construction and renovation projects increase the number of available classrooms. Therefore one is required to find a numerical measure for the effectiveness of adding classroom space.

According to our model the effectiveness of the overall education system in a school district to train learners is negatively related to the ratio of the number of learners to the available classrooms ratio (LCR) for the school. A reduction in the LCR consequently enhances the learning of all learners in the school area as it lowers the level of overcrowding in all the available classrooms. To derive a numerical measure of

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[1] School area represents the catchments area of one or two schools in a district. However in the available information of Limpopo Province, South Africa each school area represents a school.

effectiveness, an assumption is made that one unit reduction of LCR creates the same amount of additional education effectiveness whenever the LCR is greater than standard number of learners in a classroom.

Perhaps a more straight forward explanation of the measure of effectiveness used in this study is that the objective is to maximize the amount of school space per learner over the entire province. This is measured as a present value where future relief from over crowding is not as valuable as current relief. The entire maximization is carried out subject to the constraints of available funding and the inability to implement the size of construction and repair program that might be warranted by an unconstrained benefit-cost criterion.

The change of LCR with respect to a change in the number of classrooms can be mathematically calculated as the derivative of LCR with respect to the number of available classrooms (Zeinali 2008). Equation (3) expresses the rate of reduction in LCR due to increasing the classroom space, where L denotes number of learners and C denotes the number of available classrooms.

$$\left|\frac{\partial LCR}{\partial C}\right| = \left|\frac{\partial}{\partial C}\left(\frac{L}{C}\right)\right| = \frac{L}{C^2} \qquad (3)$$

The rate of reduction in LCR that is shown in equation (3) indirectly indicates the effectiveness created for any given student from increasing the space by one classroom. To calculate the total effectiveness created by the enhancement of the learning of all students in the school area, equation (3) multiplied by the number of learners in the school area giving us,

$$E = \frac{L}{C^2} \times L = \frac{L^2}{C^2} \quad . \tag{4}$$

Equation 4 expresses the total effectiveness of increasing the classroom space of a school in a way that incorporates both the number of learners and number of available classrooms in each school area. An estimation of the education effectiveness obtained by explaining classroom space in a way to realize an efficient budget allocation strategy can be derived for three possible scenarios.

1. Budget is available only for construction of new classrooms.
2. Budget is available only for renovation of old classrooms.
3. Budget is available for both construction and renovation of classrooms.

Construction of new classrooms

This scenario demonstrates the allocation of a budget that is dedicated to the construction of new classrooms. Typically classrooms are built in units of a class-block where each class-block includes more than one classroom. In this scenario we should estimate the effectiveness (that is the non-monetary measure of the enhancement in learning of all learners in a school area) derived from adding a class-block. The effectiveness obtained from adding K classrooms in a school area can be expressed as, [2]

$$E = \frac{KL^2}{C(C+K)} \qquad (5)$$

Equation (5) shows the base case estimation of the effectiveness achieved from adding K classrooms. Some adjustments need to be made to this measure of effectiveness to account for other differences in the school areas that will affect the productivity of the investments. In many countries the economic rate of return is believed to be higher for the primary level education than for the secondary level education. The difference of economic return can be incorporated in the model by increasing the effectiveness created by primary schools by a factor P.[3] This factor is set equal to the proportional additional return obtained from investing in primary schools rather than in secondary schools.[4]

If investments in education are believed to have a differential rate of return in rural areas as compared to urban areas then the effectiveness obtained from adding a classroom in the rural areas would be greater.[5] This differential can be expressed by a factor *R* for the rural areas versus base value of zero for the urban areas. For example, R = 0.2 if it is believed that the rate of return of a typical school investment (all other variables in the

[2] The effectiveness is derived from the reduction of LCR due to adding K classroom in a school area that is the difference of the old LCR and the new one. In other words instead of using the slope of the LCR curve at point (C,L) that was shown by the derivative calculation, the slope of the ark between the points of (C,L) and (C+K,L) should be used in the calculation of effectiveness.
[3] In the countries that the economic return of investment in secondary school is higher than primary school the factor P will become negative.
[4] The school areas are specified separately for primary and secondary education, based on the physical location of the available primary or secondary schools. For example if the school area is required as being a primary one, the number of learners and their projected growth rates refer to the information about the primary level learners at that area.
[5] It might be thought that the positive estimate from the rural schools might be greater than for urban schools (Haveman and Wolf 1984)

model being the same) is 20 percent higher in the rural area than the urban area. Such factors, as well as any further required adjustments, are included in an Adjustment Factor (AF) in the calculation of the effectiveness. The adjustment factor that is shown in equation (6) should be set for each school district. Therefore, one unit of the adjusted numerical measure of effectiveness has the same value in terms of its impact on educational achievement in all school districts regardless of their location or education level.

$$E = \frac{KL^2}{C(C+K)} \times AF \qquad (6)$$
$$AF = (1 + P + R + \Lambda)$$

For estimating the total impact of building a class-block on the enhancement of the education achievement, the effectiveness of a school is calculated over the entire lifetime of the classroom or school block being built. However, the effectiveness may change from year to year over time due to changes in the number of available classrooms and the number of learners in the school area. The number of available classrooms in the future depends on the number of classrooms currently available and their condition. The condition of a classroom will determine the number of years it is expected to be usable in the future.

The size of the future educational effectiveness created by the addition of a school building will be affected by the growth in the number of potential students in the area. A projection is made of the number of learners present in each school area each year over time and then the effectiveness index for each year is calculated[6]. Equation (7) shows the effectiveness for each year, where g_n stands for the growth rate in the number of learners from year$_{n-1}$ to year$_n$.

$$E_1 = \frac{KL_0^{\,2}(1+g_1)^2}{C_1(C_1+K)} \times AF$$
$$E_2 = \frac{KL_0^{\,2}(1+g_1)^2(1+g_2)^2}{C_2(C_2+K)} \times AF \qquad (7)$$
$$\mathrm{M}$$
$$E_n = \frac{KL_0^{\,2}(1+g_1)^2(1+g_2)^2\,\mathrm{K}\,(1+g_n)^2}{C_n(C_n+K)} \times AF$$

In this study the effectiveness measure is estimated in present value terms. First the effectiveness index is estimated for each year for the next *n* years from the period when the classroom is added. The series of index values are then discounted back to the current planning period. The total of all discounted effectiveness is denoted as the discounted effectiveness (DE) and used as the measure of the effectiveness to estimate the cost effectiveness ratio. Equation (8) shows the calculation of the DE, assuming that construction of a class-block is accomplished in one year.

$$DE = \frac{E_1}{(1+r)} + \frac{E_2}{(1+r)^2} + \Lambda + \frac{E_n}{(1+r)^n} \qquad (8)$$

To incorporate the value of time into the analysis of investments in education, the future stream of effectiveness created as a consequence of the investment in a school building must also be discounted by the opportunity cost of capital (*r*).

[6] Defining a growth rate for each year gives the opportunity for the analyst to model any geometric growth projection for the areas.

To find the best strategy for the budget allocation, the cost effectiveness ratio is calculated for each school area by dividing the given cost of construction of a new class-block by the DE of the school area. The school area with the lowest cost effectiveness ratio is then ranked first for financing from the budget allocation. Amongst all the school areas being considered the most effectiveness will be obtained per unit of cost if a class-block is built in that school area. To find the next place to build a class-block the cost effectiveness ratio for the school area chosen for building the first school block must be updated. The DE is recalculated for that school area taking into consideration that the school area will now have K more available classrooms from the next year onward. After recalculating the new cost effectiveness ratios, the school area now with the lowest cost effectiveness ratio is selected to be the second location where a new class-block is to be built. In the same way the ranking is continued until the cumulative cost in a given year of the construction program becomes equal to the available budget. Using this method of prioritization, the list of selected schools to be build at the end of analysis illustrates the most efficient strategy for the location of class-block investments[7].

Renovation of old classrooms

In this scenario the problem is to find which of the classrooms that are in need of repair that should be renovated in order to create the most benefits for the education system. It is assumed that the renovation of a classroom will lengthen the useful life of an old

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[7] A school area may become selected for times. The number of times [that it is] selected gives us the total number of class-blocks that should be built in that school area.

classroom to that of a new classroom.[8] In other words, renovation of an old classroom in terms of effectiveness is the same as building a new classroom in the year that the old classroom is expected to become unusable.

To find the effectiveness of renovation of an old classroom the same method is used as in the previous scenario. When a classroom becomes unusable in a school area the number of available classrooms decreases by one, thus the LCR of the school area increases and the effectiveness achieved from the renovation of any of the other classrooms in that school area increases after the period that the repaired classroom would have otherwise become unusable. [9] The future classroom situation in each school area is simulated as if there was no renovation project. Then using the number of available classrooms and number of learners in each school area the effectiveness index is calculated for each year. In renovation, however, the classrooms are repaired one by one. Therefore the effectiveness should be calculated according to change of LCR with respect to the addition of one classroom. Equation (9) is derived from equation (5) by setting K equal to one and expresses the effectiveness of repairing of one classroom.

$$E = \frac{L^2}{C(C+1)} \qquad (9)$$

In the same manner as before, the effectiveness that is shown in equation (9) should be adjusted for the estimated differences in the economic return on investment in the rural or the urban areas and between primary and secondary education. For this calculation the

[8] This assumption is not far from those used in practice. For instance in most of the States of the USA the useful life of a renovated school is considered to be equal to the new one. (http://www.saveourlandsaveourtowns.org/neighborhoodschools.html)

[9] According to the expected usable life of each old classroom, the number of available classrooms is estimated for the *n* coming years.

number of learners and available classrooms in the future are also needed. Using the same procedure as in the previous scenario, the future number of learners in each school area is projected using a growth rate for each year.

After finding the effectiveness produced by the renovation for each year over the life of the classroom the DE is calculated according to the equation (8). However, it is not quite the same as the previous scenario because of the different periods of time that the classrooms may be usable. To find the DE of each classroom that is renovated the effectiveness should be calculated from the period that the old classroom will become unusable. If the classroom will become unusable in *m* years then the E should be calculated for each period from *m* to *n* and then discounted back to the period where the renovation is taking place. In this case *n* is the number of years of like of a classroom that is renovated in year 0. This is shown as follows:

$$DE = \frac{E_m}{(1+r)^m} + \frac{E_{m+1}}{(1+r)^{m+1}} + \Lambda + \frac{E_n}{(1+r)^n} \qquad (10)$$

The cost effectiveness ratio is then estimated using the estimated cost of the renovations. A part of these costs is the expense of sending a construction team with their equipment to a school. If a renovation team is already set up in a school to repair one classroom, then the cost of the renovation of any other classroom in the school should be less than the estimated cost of repairing the classroom as a stand alone project. Thus after choosing a classroom to be repaired, in a school, the cost of renovation of other classrooms in need of repair in the same school should be reduced by the amount of the normal setting up costs that are saved. This effect is incorporated in this model by making reduction in the estimated cost of renovation all other classroom in a school once the first classroom has been selected in a school for renovation.

Using the same criterion as before, the classroom with the lowest cost effectiveness ratio is chosen in each step till the cumulative cost of renovation of the chosen classrooms becomes equal to the available budget. In this scenario, however, after the most efficient classroom for renovation is chosen, that classroom is erased from the budget allocation list. The cost effectiveness ratio is then updated for all classrooms in the same school area considering that the renovation team is present in the school area and, hence, the cost of repairing other classrooms in the same school area are somewhat decreased.

Construction and Renovation

In this last scenario the allocation of a budget for both the construction of new class-blocks and the renovation of old classrooms is carried out jointly. Both construction and renovation opportunities are ranked at the same time. The effectiveness of the construction of a new class-block in this scenario, however, is now also dependent on the future condition of the old classrooms in the same area. For example, if one district has some old classrooms needing repair and another one does not, if everything else is equal, the effectiveness of building a new class-block should be greater for the school district that has old classrooms needing repair.

To develop a general model, the future condition of all school districts, the number of available classrooms and the number of learners in each coming year are simulated. This is done assuming that no construction or renovation project is being carried out (the without project case). According to this model the DE of construction of a class-The DE is calculated for old classrooms needing repair in the district. Cost effectiveness ratios are estimated using the given costs and the DE of each of the investments. Using the same procedure as before, the investment (construction or renovation) with the least cost effectiveness ratio is chosen for the first budget allocation. The cost of renovations and DE are then updated for the school area and the cost effectiveness ratios are recalculated. The investment with the least cost effectiveness ratio is then chosen for the second budget allocation.

The ranking and recalculation of the cost effectiveness ratios are carried out until the cumulative budget of cost of construction and renovation becomes equal to the available budget. The list of the chosen investments displays the most efficient strategy to allocate the available funds amongst the investments in the different school areas.

Simulation of Model

To illustrate the procedure of the budget allocation, the model is simulated for a situation that includes both construction and renovation. A set of data based on the school situation of Limpopo Province, South Africa is used to display how the suggested model would operate in practice. This data set is based on the available information from the Department of Public Works of Limpopo Province, South Africa 2002 as reported by Jenkins and Klevchuk (2004).

Assume that an amount of R 4,400,000 is allocated for the enhancement of the infrastructure in education through building new classrooms or repairing old ones. The objective is only to obtain the highest possible effectiveness in improving the education system. In the sample chosen to illustrate the operation of this model there are 8 school districts in both rural and urban areas. Some of them are defined for the primary level of education and the others are defined for the secondary education level. The number of learners and available classrooms are available for each school area. If the projected growth of the number of learners in each school area is positive it is specified as one average growth rate for the next 20 years. However, in the areas that the growth rate is projected to be negative the projected growth rate for the second decade is set equal to zero. Table 1 displays the available information for each of these school areas.

Table 1. Condition of the 8 school areas

Location	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8
Primary (P) or Secondary (S)	P	P	S	S	P	S	P	P
Rural (R) or Urban (U)	R	U	R	R	U	R	U	R
Total Number of Learners	280	1000	550	1400	800	450	600	950
Available Classrooms	3	17	6	21	11	6	8	9
Projected Annual Growth Rate of The Number of Learners	1.0%	4.0%	0.0%	-2.0%	3.5%	-4.0%	1.0%	1.5%

The economic returns of investments in different levels of education have been estimated in many countries by George Psacharopoulos and Harry Anthony Patrinos (1994). According to their results the return of investments in primary level education in South Africa is 22.1% and in secondary level education 17.7%. Thus the factor P in equation (4) that reflects the difference of these two rates as a percentage of the rate of return from secondary education should be set at 25% for this case[10]. The target number of the learners per classroom is set at 40 for primary level school areas and 35 for secondary

[10] Investments in primary schools have a 25% greater return than in secondary schools.

level school areas. In addition, as the education systems are thought to yield a higher social return (greater externalities) from education of children in the rural areas as compared to the urban areas in South Africa, the factor R in the equation (4) is set equal to 0.2 for rural schools in South Africa.

The new classrooms are added in units of class-blocks consisting of 4 classrooms with a construction cost R 420,000 per class-block. Hence in the calculation of the effectiveness of a new class-block the factor k in the equation (5) should be set equal to 4. The number of years that should be taken into consideration in the analysis is set equal to 20 years assuming that each repaired or built classroom will be fully operational for the next 20 years.

Table 2 displays the classrooms needing repair in each school area. The classrooms that need serious renovation are categorized into to states. Condition 1 indicates that the classroom will become unusable in one year's time (m=1) and Condition 2 indicates that the classroom will become unusable in four years' time (m=4). An assumption is made that the renovation will be carried out during the school break and does not decrease the available classrooms for the current year.

Table 2. Situation of classrooms needing repair

Location		Condition	Renovation Cost (R '000s)
S. 2	Class 2.A	1	100
	Class 2.B	1	80
	Class 2.C	2	40
	Class 2.D	2	50
	Class 2.E	1	95
S. 3	Class 3.A	2	35
S. 4	Class 4.A	1	100
	Class 4.B	2	45
	Class 4.C	2	60
	Class 4.D	1	95
	Class 4.E	1	85
	Class 4.F	1	90
	Class 4.G	1	110
S. 5	Class 5.A	2	40
	Class 5.B	1	90
S. 7	Class 7.A	2	50
S. 8	Class 8.A	1	120
	Class 8.B	2	45

According to equation (10) the DE of each classroom is estimated and then the cost effectiveness ratio is calculated. In this example since there are only 2 conditions that show the period that the classroom will still be usable without renovation, we calculate the DE of each school area for both conditions.

A list is now prepared for the budget allocation including the repairing of all classrooms needing repair, and also for building a new class-block in each school area. The DE is calculated for both classrooms needing repair and new class-blocks. Then according to the given cost of construction and renovation, the cost effectiveness ratio is estimated for each investment. The cost effectiveness ratio makes it possible to prioritize different types of investment in a common set of rankings. Regardless of the type of investments, the investment should be selected that has the highest return in terms of effectiveness.

Thus the investment with the least cost effectiveness ratio is chosen as the first budget allocation. Table 3 displays the result of the first budget allocation. The repair of Class 8.B has the lowest cost effectiveness ratio of 0.010 amongst all the investments across all areas, hence it is ranked first in the budget allocation.

Table 3. Results of the first budget allocation for the construction and renovation investments

BUDGET ALLOCATION #1						
LOCATION		COSTS		EFFECTIVENESS	RANKING	
School Area	Class	Condition	Cost (R'000s)	Discounted Incremental Effectiveness	Cost Incremental Effectiveness Ratio	Budget Allocation Ranking
S. 1	Class-Block	New	420	5008	0.084	25
S. 2	Class-Block	New	420	9751	0.043	14
	Class 2.A	1	100	2989	0.033	11
	Class 2.B	1	80	2989	0.027	8
	Class 2.C	2	40	2549	0.016	2
	Class 2.D	2	50	2549	0.020	5
	Class 2.E	1	95	2989	0.032	10
S. 3	Class-Block	New	420	6778	0.062	22
	Class 3.A	2	35	1908	0.018	4
S. 4	Class-Block	New	420	6202	0.068	23
	Class 4.A	1	100	1849	0.054	20
	Class 4.B	2	45	1291	0.035	12
	Class 4.C	2	60	1291	0.046	17
	Class 4.D	1	95	1849	0.051	19
	Class 4.E	1	85	1849	0.046	15
	Class 4.F	1	90	1849	0.049	18
	Class 4.G	1	110	1849	0.059	21
S. 5	Class-Block	New	420	9040	0.046	16
	Class 5.A	2	40	2409	0.017	3
	Class 5.B	1	90	2927	0.031	9
S. 6	Class-Block	New	420	2336	0.180	26
S. 7	Class-Block	New	420	5113	0.082	24
	Class 7.A	2	50	1348	0.037	13
S. 8	Class-Block	New	420	16139	0.026	7
	Class 8.A	1	120	5511	0.022	6
	Class 8.B	2	45	4334	0.010	1

To find the investment to be ranked second, Class 8.B is first deleted from the list and the DE is recalculated for Class 8.A and a new class block in School area 8. In addition, the cost of renovation of Class 8.B drops by 10% due to the presence of a renovation team in School area 8. According to the updated measures of the DE and the cost of the investment, the cost effectiveness ratios are recalculated. The investment with the lowest cost effectiveness ratio is then selected for the second budget allocation. Table 4 shows the results of the ranking for the second budget allocation.

Table 4. Results of the second budget allocation for the construction and renovation investments

BUDGET ALLOCATION #2						
LOCATION		COSTS		EFFECTIVENESS	RANKING	
Shool Area	Class	Condition	Cost (R'000s)	Discounted Incremental Effectiveness	Cost Incremental Effectiveness Ratio	Budget Allocation Ranking
S. 1	Class-Block	New	420	5008	0.084	24
S. 2	Class-Block	New	420	9751	0.043	13
	Class 2.A	1	100	2989	0.033	10
	Class 2.B	1	80	2989	0.027	6
	Class 2.C	2	40	2549	0.016	1
	Class 2.D	2	50	2549	0.020	4
	Class 2.E	1	95	2989	0.032	9
S. 3	Class-Block	New	420	6778	0.062	21
	Class 3.A	2	35	1908	0.018	3
S. 4	Class-Block	New	420	6202	0.068	22
	Class 4.A	1	100	1849	0.054	19
	Class 4.B	2	45	1291	0.035	11
	Class 4.C	2	60	1291	0.046	16
	Class 4.D	1	95	1849	0.051	18
	Class 4.E	1	85	1849	0.046	14
	Class 4.F	1	90	1849	0.049	17
	Class 4.G	1	110	1849	0.059	20
S. 5	Class-Block	New	420	9040	0.046	15
	Class 5.A	2	40	2409	0.017	2
	Class 5.B	1	90	2927	0.031	7
S. 6	Class-Block	New	420	2336	0.180	25
S. 7	Class-Block	New	420	5113	0.082	23
	Class 7.A	2	50	1348	0.037	12
S. 8	Class-Block	New	420	13643	0.031	8
	Class 8.A	1	108	4548	0.024	5

As shown in Table 4, Class 2.C has the lowest cost effectiveness ratio in the second budget allocation. The updated cost effectiveness ratios of Class 8.A and a new class block in School area 8 have both increased due to the decrease of DE that comes about due to the additional classroom capacity in district 8 because of the renovation of Class 8.B. The renovation of Class 8.B gives district 8 one more available classroom from the year 4. The change of the cost effectiveness ratio, however, was greater for the new class-block rather than Class 8.A since the cost of the renovation of Class 8.A dropped by 12,000 due to the presence of the renovation team at School area 8. The cost reduction partially compensate for the reduction in the DE due to the lower (L/C) ratio.

The prioritization process for budget allocation continues until the cumulative cost of construction and renovation becomes equal to R 4,400,000. Table 5 display the most efficient strategy for the allocation of the available budget for this sample of school districts.

Table 5. The most efficient strategy for the construction and renovation investments

Rank	Location		Condition	Cost (R '000s)	Discounted Effectiveness	Cost Effectiveness Ratio	Cumulative Cost (R '000s)
1	S. 8	Class 8.B	2	45	4334	0.010	45
2	S. 2	Class 2.C	2	40	2515	0.016	85
3	S. 5	Class 5.A	2	40	2503	0.016	125
4	S. 3	Class 3.A	2	35	1908	0.018	160
5	S. 2	Class 2.D	2	45	2156	0.021	205
6	S. 8	Class 8.A	1	108	4548	0.024	313
7	S. 2	Class 2.B	1	72	2292	0.031	385
8	S. 5	Class 5.B	1	81	2556	0.032	466
9	S. 4	Class 4.B	2	45	1291	0.035	511
10	S. 7	Class 7.A	2	50	1348	0.037	561
11	S. 8	Class Block	New	420	11194	0.038	981
12	S. 2	Class 2.E	1	86	2006	0.043	1067
13	S. 4	Class 4.E	1	77	1688	0.045	1143
14	S. 2	Class 2.A	1	90	1770	0.051	1233
15	S. 4	Class 4.C	2	54	997	0.054	1287
16	S. 4	Class 4.F	1	81	1382	0.059	1368
17	S. 5	Class Block	New	420	6817	0.062	1788
18	S. 4	Class 4.D	1	86	1237	0.069	1874
19	S. 8	Class Block	New	420	5926	0.071	2294
20	S. 3	Class Block	New	420	5506	0.076	2714
21	S. 2	Class Block	New	420	5394	0.078	3134
22	S. 4	Class 4.A	1	90	1113	0.081	3224
23	S. 1	Class Block	New	420	5008	0.084	3644
24	S. 7	Class Block	New	420	4337	0.097	4064
25	S. 4	Class 4.G	1	99	1007	0.098	4163
26	S. 5	Class Block	New	420	3947	0.106	4583
Total Cost (R '000s)							**4163**
Total Construction Cost (R '000s)							**2940**
Total Rehabilitation Cost (R '000s)							**1223**

In total, 25 investments with a total cost of R 4,163,000 are selected including repairing all the 18 classrooms needing repair and building 7 new class-blocks. The renovation of 10 old classrooms heads the ranking before any new construction should be undertaken. Giving the highest priority to renovation of classrooms that are usable for some years may seem strange to policy makers and engineers. However, as this study has explained, in the long run the chosen investments will create the most effectiveness for the enhancement of the education system.

The growth rate of population in different districts is an important factor for decision makers. In our model this factor is incorporated through calculating the effectiveness for each year considering the projected population of learners in that year. To see how the results of the suggested model vary due to changes in the assumed growth rate of learners, another example is given. Suppose the growth rate of school area 2 is set equal to zero for the next 20 years (while in the first ranking it had a growth rate of 4%). Table 6 illustrates the changes in the priorities due to a reduction in growth rate of this school area.

Table 6. Variation of priorities of investments in School area 2 due to decreasing the growth rate from 4% to zero

Rank	Location		Condition	Cost (R '000s)	Discounted Effectiveness	Cost Effectiveness Ratio	Cumulative Cost (R '000s)
1	S. 8	Class 8.B	2	45	4334	0.010	45
2	S. 5	Class 5.A	2	40	2503	0.016	85
3	S. 3	Class 3.A	2	35	1908	0.018	120
4	S. 8	Class 8.A	1	108	4548	0.024	228
5	S. 5	Class 5.B	1	81	2556	0.032	309
6	S. 4	Class 4.B	2	45	1291	0.035	354
7	S. 2	Class 2.C	2	40	1106	0.036	394
8	S. 7	Class 7.A	2	50	1348	0.037	444
9	S. 8	Class-Block	New	420	11194	0.038	864
10	S. 4	Class 4.E	1	77	1688	0.045	941
11	S. 2	Class 2.D	2	45	948	0.047	986
12	S. 4	Class 4.C	2	54	997	0.054	1040
13	S. 4	Class 4.F	1	81	1382	0.059	1121
14	S. 2	Class 2.B	1	72	1185	0.061	1193
15	S. 5	Class-Block	New	420	6817	0.062	1613
16	S. 4	Class 4.D	1	86	1237	0.069	1698
17	S. 8	Class-Block	New	420	5926	0.071	2118
18	S. 3	Class-Block	New	420	5506	0.076	2538
19	S. 4	Class 4.A	1	90	1113	0.081	2628
20	S. 2	Class 2.E	1	85.5	1037	0.082	2714
21	S. 1	Class-Block	New	420	5008	0.084	3134
22	S. 7	Class-Block	New	420	4337	0.097	3554
23	S. 4	Class 4.G	1	99	1007	0.098	3653
24	S. 2	Class 2.A	1	90	915	0.098	3743
25	S. 5	Class-Block	New	420	3947	0.106	4163
26	S. 8	Class-Block	New	420	3669	0.114	4583
Total Cost (R '000s)							**4163**
Total Construction Cost (R '000s)							**2940**
Total Rehabilitation Cost (R '000s)							**1223**

As a result of reducing the growth rate in School area 2 from 4% to zero, the priorities of investments in that area decreases significantly and the construction of a new class-block that was chosen before does not appear now amongst the chosen investments. Hence, this model is able to capture not just the current or before project situation in a school area but changes the priorities of investment decisions today to the future demographics of an area.

CONCLUSION

Around the world the decisions concerning the location of school buildings has been the focus of much political lobbying and controversy. As a result many of the locational decisions for school buildings have produced an inefficient allocation of investments for this sector.

While the criteria used in this paper to rank investment opportunities may be still imperfect if reflects a major improvement over current practice for many countries. The cost effectiveness model was designed under the condition that it must use only the information that is now readily available in the Provinces of South Africa. The information comes from the survey of public sector assets carried out by the Department of the Public works in the Provincial Governments. More sophisticated education information systems will no doubt enable a more accurate analysis to be undertaken of investment alternatives. However such information systems are costly to design, implement, and maintain. Furthermore, it may take a decade before being fully comprehensive and available.

Given the information typically available in many less developed countries, the model presented here might be an appropriate first step in the design of a more rational system of setting locational priorities for investments in school buildings. It also highlights the importance of the repair decisions of the existing structures as a potentially efficient alternative to the construction of new ones. The underfunding of repair is a chronic characteristic of the public sector budget of most developing countries. This model seeks to put a spotlight on this issue.

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