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Nathaniel Kayode Oladejo
University for Development Studies

Salawu Sulyman
Landmark University

Olasunkanmi M. Bamiro
Landmark University

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APPLICATION OF OPTIMIZATION PRINCIPLES IN CLASSROOM ALLOCATION USING LINEAR PROGRAMMING

N. K Oladejo*, A. Abolarinwa, S.O Salawu, M.O Bamiro and A.F Lukman
Physical Sciences Department, Landmark University, Kwara State, Nigeria

H.I Bukari
Mathematics Department, Bagabaga College of Education, Tamale, Ghana
*corresponding author

ABSTRACT

This paper deal with the application of optimization principle in solving the problem of over-allocation and under-allocation of the classroom space using linear programming in Landmark University, Nigeria. A linear programming model was formulated based on the data obtained from the examination and lecture timetable committee on the classroom facilities, capacities and the number of students per programme in all the three (3) Colleges to maximize the usage of the available classroom space and minimizes the congestion and overcrowding in a particular lecture room using AMPL software which revealed that 16 out of 32 classrooms available with a seating capacity of 2066 has always been used to accommodate the current student population of 2522 which always causes overflow and congestion in those concentrated classroom because the remaining 16 classroom of the seating capacity of 805 were underutilized. Meanwhile if the projected seating capacity of 3544 as revealed by the AMPL software in all these 32 classroom were fully utilized, this indicated that an additional 1022 i.e.(3544-2522) students can be fully absorbed comfortably with the existing 32 classrooms in both of the three (3) colleges if the seating capacities are fully managed and maximized. This will helps the school management to generate additional income of N 585,606,000.00 i.e. (1022 × 573,000) as school fees using the same classroom facility and as well as the existing seating capacity.

Keywords: Allocation, classroom, linear, optimization, programming, maximize

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1. INTRODUCTION

The problem of allocating scarce resource to satisfy unlimited human needs has been and continues to be a global phenomenon confronting both the managers, administrators, entrepreneurs, heads of institutions and individuals alike. Allocation of resources to areas of space such as rooms, satisfying as many requirements and constraints as possible can be called a Space allocation**.** Arsham (1998) presented a procedure for allocating classrooms in an educational institution which was based on a linear programming model in which a penalty function is minimized. With the default values of some parameters provided by the procedure, the model first assigns as many rooms to the requests as possible.

The ideal solution in the space allocation problem is one where all the entities were optimally allocated, no space is wasted or overused and every additional requirements and constraints have been satisfied. Classroom allocation has been an issue affecting many organisations, companies and schools such as Landmark University of which the paper try to find a lasting solution to the problem using Linear programming method which was developed as a discipline by George Danzig (1947) always refers to the founder who devised the simplex method in 1947 which was motivated initially by the need to solve complex planning problems in wartime operations. Its' development accelerated rapidly in the post-war period as many industries found valuable uses for linear programming and George Danzig who established the theory of duality also in 1947.

Karmarkar (1984) opined that a better way to consistently and effectively allocate classrooms is to use a computer-assisted system that will keep track of all classrooms on campus along with specific details about those rooms that can automatically suggest efficient pairings with the courses offered for a given semester. The efficiency will be judged based on many factors, most importantly being that the size of each room is used effectively. Rajgopal and Bricker (1990) stated that Mathematical programming that solves the problem of determining the optimal allocation of limited resources required to meet a given objective, is the linear programming, a method of allocating limited resources to competing needs in the best way in order to ensure optimality.

Raz, and Bricker (1990) presented the ellipsoid method, guaranteed to solve any linear program in a number of steps which is a polynomial function of the amount of data defining the linear program. Consequently, the ellipsoid method is faster than the simplex method in contrived cases where the simplex method performs poorly. In practice, however, the simplex method is far superior to the ellipsoid method. Abad and Banks (1993) introduced an interior-point method for linear programming, combining the desirable theoretical properties of the ellipsoid method with practical advantages of the simplex method. Its success initiated an explosion in the development of interior-point methods. These do not pass from vertex to vertex, but pass only through the interior of the feasible region. Though this property is very easy to state, the analysis of interior-point methods is a subtle subject which is much less easily understood than the behaviour of the simplex method. Interior-point methods are now generally considered competitive with the simplex method in most cases, though not all, applications, and sophisticated software packages implementing them are now available.

2. LINEAR PROGRAMMING PROBLEM

A Linear programming (LP) is one of the most widely used optimization techniques and perhaps the most effective method. The term linear programming was coined by George Dantzig in 1947 to refer to problems in which both the objective function and constraints are provided. It is a problem of optimizing linear objective in the decision variables $x_1, x_2 \ldots\ldots x_n$ subject to linear inequality or inequality constraints on the X .

We then give our standard form of linear programming as:

$$Maximize \quad F=\sum_{j=1}^{n} C_i X_j \tag{1}$$

$$Subject \quad to$$

$$\sum_{j=1}^{n} a(i\,j)X_j = b_i \,.i = 12...n \tag{2}$$

$$l_j \le X \le u_j.\, j = 12...n$$

Where C_j *arethen objective function coefficients* $a(i\,j)$ *andb are parameters in them linearinequality constrants and* l_j *and* u_j *are lowerandupperboundswith* $l_j \le u_j$.

Both l_j *and* u_j *maybe positiveornegative*

2.1. Formulation of LP Model

Mathematical linear programming models where formulated to determine how to adequately allocate class spaces to each department which consist of types of classroom, seating capacities, number of such classroom according to the departments and programmes in each of the three (3) colleges as well as the total number of the students in the each of the departments according to the levels which was collected from the Chairman of the University lecture and examination time table committee.

The specified LP model for the attainment of the objective function is as follows:

$$Minimize \quad Z = \sum C_j X_i$$

$$Subject \quad to$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = b_1$$
$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + a_{15}x_5 + a_{16}x_6 + a_{.17}x_7 + a_{18}x_8 \le b_2$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 + a_{25}x_5 + a_{26}x_6 + a_{27}x_7 + a_{28}x_8 \le b_3$$
$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 + a_{35}x_5 + a_{36}x_6 + a_{37}x_7 + a_{38}x_8 \le b_4$$
$$a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 + a_{45}x_5 + a_{46}x_6 + a_{47}x_7 + a_{48}x_8 \le b_5$$
$$a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + a_{54}x_4 + a_{55}x_5 + a_{56}x_6 + a_{57}x_7 + a_{58}x_8 \le b_6$$
$$a_{61}x_1 + a_{62}x_2 + a_{63}x_3 + a_{64}x_4 + a_{65}x_5 + a_{66}x_6 + a_{67}x_7 + a_{68}x_8 \le b_7$$
$$a_{71}x_1 + a_{72}x_2 + a_{73}x_3 + a_{74}x_4 + a_{75}x_5 + a_{76}x_6 + a_{77}x_7 + a_{78}x_8 \le b_8$$
$$a_{81}x_1 + a_{82}x_2 + a_{83}x_3 + a_{84}x_4 + a_{85}x_5 + a_{86}x_6 + a_{87}x_7 + a_{88}x_8 \le b_9$$
$$a_{91}x_1 + a_{92}x_2 + a_{93}x_3 + a_{94}x_4 + a_{95}x_5 + a_{96}x_6 + a_{97}x_7 + a_{98}x_8 \le b_{10}$$
$$a_{101}x_1 + a_{102}x_2 + a_{103}x_3 + a_{104}x_4 + a_{105}x_5 + a_{106}x_x + a_{107}x_7 + a_{108}x_8 \le b_{11}$$
$$x_1 \ge 0,\ i = 1,2,3,....\ n \tag{3}$$

This which can be transformed into the following

$$
\begin{aligned}
&\textit{Minimize} \quad Z = \sum C_j X_i \\
&\textit{Subject to} \\
&x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = b_1 \\
&x_1 + \leq b_2 \\
&+ x_2 + \leq b_3 \\
&+ x_3 + \leq b_4 \\
&+ x_4 + \leq b_5 \\
&+ x_5 + \leq b_6 \\
&+ x_6 + \leq b_7 \\
&+ x_7 + \leq b_8 \\
&+ x_8 + \leq b_9 \\
&+ x_9 + \leq b_{10} \\
&+ x_{10} + \leq b_{11} \\
&x_1 \geq 0,\ i = 1,2,3,\ldots.n
\end{aligned}
\tag{4}
$$

2.2. Modelling Technique:

This classroom space allocation problem is considered as a linear programming problem and this classroom space was categorized into types according to the number of seats, and the type of sitting/equipment/capacity available. The students were considered according to the level in the classes based on the programme and the level of the students as follows.

(i).We let the capacity of each category (type) of a classroom be: $C_i = C_1, C_2, C_3, C_4 \ldots C_n$

For $i = 1, 2, 3 \ldots n$

Where

$$C_1 = \text{ the capacity of a room of type1}$$
$$C_2 = \text{ the capacity of a room of type 2}$$
$$C_3 = \text{ the capacity of a room of type 3}$$
$$C_4 = \text{ the capacity of a room of type 4}$$

$C_5 =$ the capacity of a room of type 5

(ii). we let the classrooms be categorized into types as: $x_i = x_1, x_2, x_3, x_4, \ldots x_n$

For $i = 1,2,3,4 \ldots. n$ based on the capacities of the rooms, where

$$x_1 = \text{ classroom type 1 with a seating capacity } C_1$$
$$x_2 = \text{ classroom type 2 with a seating capacity of } C_2$$
$$x_3 = \text{ classroom type 3 with a seating capacity of } C_3$$
$$x_4 = \text{ classroom type 4 with a seating capacity of } C_4$$

$x_5 =$ classroom type 5 with a seating capacity of C_5 (3).We let the number of classrooms of each type be: $a_1, a_2, a_3 \ldots. a_n$

Where;

$$a_1 = \text{ number of rooms of classroom type 1}$$
$$a_2 = \text{ number of rooms of classroom type 2}$$

(iii) We let the total available classroom space of all the types of classrooms denoted by d.

Then

$$d = \sum_{i=1}^{n} a_i c_i \tag{5}$$

Where: $a_1 \ldots\ldots. a_n$ is the number of classrooms of each type ,

d is the total available classroom space of all the types of classrooms

$c_1 .... a_{cn}$ is the capacity of each category (type) of a classroom

3. DATA COLLECTION AND ANALYSIS OF RESULTS

The primary data collected from the Landmark University Chairman examination committee which consist of types of classroom, seating capacities, number of available classroom by category, list of the Departments and programmes in each of the three (3) colleges as well as the total number of the students in the Departments according to the levels which was collected from the chairman of the University time table committee. The list of classroom types currently utilized in the school is as follows:

1. Wing A, we have A01, A02, A03, A04, A11, A12, A13, A14, A21, A22, A23, A24 in NCB and A215, A315, A316 in FCB
2. Wing B, we have: B01, B02, B03, B04, B12, B13, B14, B21, B22, B23, and B24 in NCB
3. Wing C, we have: C02, C12, C13, C14 in NCB

Where NCB= New College Building and FCB= First College Building. The tables of all the class types and their respective capacities as well as their availability are given table 1 below

Table 1: Shows the classes available and their respective seating capacities

Classroom Type	Seating Capacity	No of available Classrooms
A01	92	1
A02	36	1
A13	38	1
A12	40	1
A22, A23	42	2
A03	45	1
B12, B13, B22, B23	48	4
B02, B03	55	2
C02, C12, C13	60	3
C14	70	1
A11, A14	72	2
B04, B14, B24	91	3
A315	96	1
A04, A21, A24	98	3
B01, A215	100	2
A316	104	1
B21	119	1
LT2 Ground Floor	350	1
LT1 First Floor	394	1
Total	2861	32

Table 2 shows number of students in each College, Department and Programme per level

		LEVEL					
	DEPT	**100**	**200**	**300**	**400**	**500**	**TOTAL**
CAS	Agric. Econs.	15	12	18	4	7	56
	Crop Sc.	9	7	5	4	-	25
	Animal Sc.	10	14	6	4	4	38
	Agric. Eng. Ext.	5	8	5	7	2	27
	Soil Sc.	2	4	3	2	2	13
CSE	Computer Sc.	114	52	36	25	-	227
	Biological Sc.	68	66	54	39	-	227
	Physical Sc.	12	9	17	18	-	56
	Civil Eng.	86	45	46	47	27	251
	Chem. Eng.	30	30	20	25	28	133
	Mech. Eng.	97	72	48	36	35	288
	EIE	86	57	58	65	50	316
	ABE	8	23	14	12	8	65
CBS	Accounting	61	69	52	37	-	219
	Bus. Admin.	21	27	30	27	-	105
	Economics	45	33	22	32	-	132
	Sociology	31	23	18	14	-	86
	BFN	5	8	6	14	-	33
	Pol. Sc. & Int. Rel.	76	52	60	37	-	225
TOTAL		**781**	**611**	**518**	**449**	**163**	**2522**

3.1. Formulation of Linear programming

The linear Programming is hereby formulated and determines the objective function as:

$$Max : \sum_{i=1}^{n} C_i X_j \tag{6}$$

Subject to constraints;

$$\sum_{i=1}^{n} a_i c_j \leq d \qquad (i = 1,2,......................n) \tag{7}$$

Assumption:

We assumed that

I. The total number of students assigned to a number of categories of the rooms cannot exceed the total classroom space available in each of the classrooms.

II. $x_i \geq 0$ for $(i = 1, 2, 3, \dots)$ is non-negative since a number of students to be assigned to a room cannot be a negative number.

Then we set up the objective function as follows:

$$Max \quad P = 36x_1 + 38x_2 + 40x_3 + 84x_4 + 45x_5 + 192x_6 + 110x_7 + 180x_8 + 70x_9 + 144x_{10} + 273x_{11} + 92x_{12} + 96x_{13} + 294x_{14} + 200x_{15} + 104x_{16} + 119x_{17} + 350x_{18} + 394x_{19}$$

Subject to

$$19x_1+9x_2+10x_3+5x_4+2x_5+114x_6+68x_7+12x_8+86x_9+30x_{10}+97x_{11}+86x_{12}+8x_{13}+61x_{14}+21x_{15}+45x_{16}+31x_{17}+5x_{18}+76x_{19} \le 781$$
$$12x_1+7x_2+14x_3+8x_4+4x_5+52x_6+66x_7+9x_8+45x_9+30x_{10}+72x_{11}+57x_{12}+23x_{13}+69x_{14}+27x_{15}+33x_{16}+23x_{17}+8x_{18}+52x_{19} \le 611$$
$$18x_1+5x_2+6x_3+5x_4+3x_5+36x_6+54x_7+17x_8+46x_9+20x_{10}+48x_{11}+58x_{12}+14x_{13}+52x_{14}+30x_{15}+22x_{16}+18x_{17}+6x_{18}+60x_{19} \le 518$$
$$4x_1+4x_2+4x_3+7x_4+2x_5+25x_6+39x_7+18x_8+47x_9+25x_{10}+36x_{11}+65x_{12}+12x_{13}+37x_{14}+27x_{15}+32x_{16}+14x_{17}+14x_{18}+37x_{19} \le 449$$
$$7x_1+4x_2+2x_3+2x_4+27x_5+28x_6+35x_7+50x_8+8x_9 \le 163$$
$$x_1+x_2+x_3+2x_4+x_5+4x_6+2x_7+3x_8+x_9+2x_{10}+3x_{11}+x_{12}+x_{13}+3x_{14}+21x_{15}+x_{16}+x_{17}+x_{18}+x_{19} \le 32$$
$$92x_1+36x_2+38x_3+40x_4+45x_5+48x_6+55x_7+60x_8+70x_9+72x_{10}+91x_{11}+96x_{12}+98x_{13}+100x_{14}+104x_{15}+119x_{16}+350x_{17}+394x_{18} \le 2861$$
$$x_1 \le 1$$
$$x_2 \le 1$$
$$x_3 \le 2$$
$$x_4 \le 1$$
$$x_5 \le 4$$
$$x_6 \le 2$$
$$x_7 \le 3$$
$$x_8 \le 1$$
$$x_9 \le 2$$
$$x_{10} \le 3$$
$$x_{11} \le 1$$
$$x_{12} \le 1$$
$$x_{13} \le 3$$
$$x_{14} \le 2$$
$$x_{15} \le 1$$
$$x_{16} \le 1$$
$$x_{17} \le 1$$
$$x_{18} \le 1$$
$$x_1, x_2, x, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}, x_{19} \ge 0$$

Where

x_1 = Classroom type 1 with seating capacity of 36

x_2 = Classroom type 2 with seating capacity of 38

x_3 = Classroom type 3 with seating capacity of 40

x_4 = Classroom type 4 with seating capacity of 84

x_5 = Classroom type 5 with seating capacity of 45

x_6 = Classroom type 6 with seating capacity of 192

x_7 = Classroom type 7 with seating capacity of 110

x_8 = Classroom type 8 with seating capacity of 180

x_9 = Classroom type 9 with seating capacity of 70

x_{10} = Classroom type 10 with seating capacity of 114

x_{11} = Classroom type 11 with seating capacity of 273

x_{12} = Classroom type 12 with seating capacity of 92

x_{13} = Classroom type 13 with seating capacity of 96

x_{14} = Classroom type 12 with seating capacity of 294

x_{15} = Classroom type 15 with seating capacity of 200

x_{16} = Classroom type 16 with seating capacity of 104

x_{17} = Classroom type 17 with seating capacity of 119

x_{18} = Classroom type 18 with seating capacity of 350

x_{19} = Classroom type 19 with seating capacity of 394

3.2. Develop AMPL Software Programme

```
# PART 1: DECISION VARIABLES
var x1>= 0;
var x2>= 0;
var x3>= 0;
var x4>= 0;
var x5>= 0;
var x6>= 0;
var x7>= 0;
var x8>= 0;
var x9>= 0;
var x10>= 0;
var x11>= 0;
var x12>= 0;
var x13>= 0;
var x14>= 0;
var x15>= 0;
var x16>= 0;
var x17>= 0;
var x18>= 0;
var x19>= 0;
# PART 2: OBJECTIVE FUNCTION
maximize P: 36*x1 + 38*x2 + 40*x3 + 84*x4 + 45*x5 + 192*x6 + 110*x7 + 180*x8 + 70*x9 + 144*x10 + 273*x11 + 92*x12 + 96*x13 + 294*x14 + 200*x15 + 104*x16 + 119*x17 + 350*x18 + 394*x19; # Capacity of each class type
#PART 3: CONSTRAINTS
s.t. M1: 15*x1 + 9*x2 + 10*x3 + 5*x4 + 2*x5 + 114*x6 + 68*x7 + 12*x8 + 86*x9 + 30*x10 + 97*x11 + 86*x12 + 8*x13 + 61*x14 + 21*x15 + 45*x16 + 31*x17 + 5*x18 + 76*x19<= 2861; # Total of students in 100level
s.t. M2: 12*x1 + 7*x2 + 14*x3 + 8*x4 + 4*x5 + 52*x6 + 66*x7 + 9*x8 + 45*x9 + 30*x10 + 72*x11 + 57*x12 + 23*x13 + 69*x14 + 27*x15 + 33*x16 + 23*x17 + 8*x18 + 52*x19<= 2861; #  Total of students in 200level
s.t. M3: 18*x1 + 5*x2 + 6*x3 + 5*x4 + 3*x5 + 36*x6 + 54*x7 + 17*x8 + 46*x9 + 20*x10 + 48*x11 + 58*x12 + 14*x13 + 52*x14 + 30*x15 + 22*x16 + 18*x17 + 6*x18 + 60*x19<= 2861; # Total of students in 300level
s.t. M4: 4*x1 + 4*x2 + 4*x3 + 7*x4 + 2*x5 + 25*x6 + 39*x7 + 18*x8 + 47*x9 + 25*x10 + 36*x11 + 65*x12 + 12*x13 + 37*x14 + 27*x15 + 32*x16 + 14*x17 + 14*x18 + 37*x19<= 2861; # Total of students in 400level
```

s.t. M5: 7*x1 + 4*x2 + 4*x3 + 2*x4 + 2*x5 + 27*x9 + 28*x10 + 35*x11 + 50*x12 + 8*x13<= 2861; # Total of students in 500level

s.t. M6: x1 + x2 + x3 + 2*x4 + x5 + 4*x6 + 2*x7 + 3*x8 + x9 + 2*x10 + 3*x11 + x12 + x13 + 3*x14 + 2*x15 + x16 + x17 + x18 + x19<= 32; # No of available classrooms

s.t. M7: x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12 + x13 + x14 + x15 + x16 + x17 + x18 + x19>= 0;

s.t. M8: x1<= 1;

s.t. M9: x2<= 1;

s.t. M10: x3<= 1;

s.t. M11: x4<= 2;

s.t. M12: x5<= 1;

s.t. M13: x6<= 4;

s.t. M14: x7<= 2;

s.t. M15: x8<= 3;

s.t. M16: x9<= 1;

s.t. M17: x10<= 2;

s.t. M18: x11<= 3;

s.t. M19: x12<= 1;

s.t. M20: x13<= 1;

s.t. M21: x14<= 3;

s.t. M22: x15<= 2;

s.t. M23: x16<= 1;

s.t. M24: x17<= 1;

s.t. M25: x18<= 1;

s.t. M26: x19<= 1;

The part that was run for results is (example1.run);

reset;

model example1.mod;

solve;

display x1, x2, x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15, x16, x17, x18, x19, P;

3.3. The AMPL Software Results

ampl: include example1.run

MINOS 5.51: optimal solution found.

10 iterations, objective 3544

x1 = 0

x2 = 0

x3 = 0

x4 = 0

x5 = 0

x6 = 0
x7 = 0
x8 = 0
x9 = 0
x10 = 2
x11 = 3
x12 = 1
x13 = 1
x14 = 3
x15 = 2
x16 = 1
x17 = 1
x18 = 1
x19 = 1
P = 3544
That implies

$$P_{\max} = 3544$$

4. ANALYSES OF RESULTS

Analysis of the result generated from the AMPL software is presented in the table 3 below. The table shows the classes that are being utilized and those not being utilized currently as indicated in the AMPL software

Classroom Type	Seating Capacity	Available classrooms	No of classes utilized
A01	92	1	1
A02	36	1	0
A13	38	1	0
A12	40	1	0
A22, A23	42	2	0
A03	45	1	0
B12, B13, B22, B23	48	4	0
B02, B03	55	2	0
C02, C12, C13	60	3	0
C14	70	1	0
A11, A14	72	2	2
B04, B14, B24	91	3	3
A315	96	1	1
A04, A21, A24	98	3	3
B01, A215	100	2	2
A316	104	1	1
B21	119	1	1
LT2 Grd Flr	350	1	1
LT2 First Flr	394	1	1
Total	**2861**	**32**	**16**

From the results of the AMPL software, it is observed that 16 out of 32 classrooms available with a seating capacity of 2066 had been used to accommodate the current student population of 2522 students and this always causes overflow and congestion in the classroom because the remaining 16 classroom of the seating capacity of 805 were underutilized and were not always taken notice of as tabulated as fully utilized classroom and unused classroom in the table 5 and table 6 below respectively.

Meanwhile the projected seating capacity of 3544 as given by the AMPL software if all the 32 classroom were fully utilized and this indicated that an additional 1022 students can be fully absorbed comfortably with the existing 32 classrooms in all of the three (3) colleges if the seating capacity is fully utilized and maximized and this will help the school to generate additional $(1022 \times 573{,}000) = N$ 585,606,000.00 as school fees using the same classroom facility and as well as the existing seating capacity.

Table 4 shows the fully utilized classroom with its seating capacity

Classroom Type	Available classroom	Seating Capacity	No of classes utilized	Total No of seating capacity
A01	1	92	1	92
A11, A14	2	72	2	144
B04, B14, B24	3	91	3	273
A315	1	96	1	96
A04, A21, A24	3	98	3	294
B01, A215	2	100	2	200
A316	1	104	1	104
B21	1	119	1	119
LT2 Grd. Floor	1	350	1	350
LT1 First Floor	1	394	1	394
Total	**16**			**2066**

Table 5 shows not utilized classroom with its seating capacity

Classroom Type	Available classroom	Seating Capacity	No of classes not utilized	Total No of seating capacity
A02	1	36	0	36
A13	1	38	0	38
A12	1	40	0	40
A22, A23	2	42	0	94
A03	1	45	0	45
B12, B13, B22, B23	4	48	0	192
B02, B03	2	55	0	110
C02, C12, C13	3	60	0	180
C14	1	70	0	70
Total	**16**			**805**

5. CONCLUSION

In this paper, we have fully determine the total number of seating capacity in each of the available classroom in Landmark University and proposed appropriate solution to the classroom allocation problem using linear programming by maximizing the existing 32 classroom available to accommodate about 3544 additional students using the same and existing classroom capacity and this probably will earn the school management an additional *N* 585,606,000.00 (1022 × 573,000) as school fees using the same classroom facility and as well as the existing seating capacity.

REFERENCES

[1] Arsham H ‘Optimization Techniques 1: Links among a Linear System of Equations, Matrix Inversion, and Linear Program Solver Routines, Journal of Mathematical Education in Science and Technology, 29(5), (1998). 764-769.

[2] George Danzig. The Dantzig simplex method for linear programming. IEEExplore Vol.2 issue.1 (1947) pp 234-241

[3] Huhn P. and Borgwardt K. H. Interior-point methods: worst case and average case Analysis of a phase-i algorithm and a termination procedure, Journal of Complexity Vol.18, Issue 3, (2002). pp 833-910

[4] Karmarkar N. A new polynomial-time algorithm for linear programming, Combinatorica 4(4) (1984) pp. 373-395

[5] Rajgopal, J. and Bricker, D. L. Polynomial Geometric Programming as a Special Case of Semi-Infinite Linear Programming, Journal of Optimization Theory and Application. Vol. 66, (1990). pp. 455-475.

[6] Raz, T. and Bricker, D. L. Optimal and Heuristic Solutions to the Variable Inspection Policy Problem, Computers and Operations Research, Vol. 18, (1990). pp. 115-123.

[7] Abad P.L. and Banks W.J. New LP based heuristics for the classification problem, European Journal of Operational Research, (1993).

[8] Lin, E. Y. H. and Bricker, D. L. Implementing the Recursive APL Code for Dynamic Programming, APL90 Conference Proceedings, Copenhagen, (1990). pp. 239-250.

[9] Rajgopal, J. and Bricker, D. LPolynomial Geometric Programming as a Special Case of Semi-Infinite Linear Programming, Journal of Optimization Theory and Applications, Vol. 66,. (1990). pp. 455-475.

[10] Yarmish G. Wavelet decomposition via the standard tableau simplex Method of liner programming, Polytechnic University, Brooklyn, NY. (2001).

[11] Bricker, D. L. (1977). Reformulation of Special Ordered Sets for Implicit Enumeration Algorithms with Applications in Non-convex Separable Programming, Vol. 9 (1977), AIIE Transactions