International Journal of Engineering Innovation & Research
Volume 3, Issue 3, ISSN: 2277 – 5668

An Operation Planning Model for New Postgraduate Programmes

I. S. Oladeji
Department of Industrial and Production Engineering,
University of Ibadan, Ibadan, Nigeria
Email: ibk011@yahoo.com

V. O. Oladokun
Department of Industrial and Production Engineering,
University of Ibadan, Ibadan, Nigeria
Email: victordokun@yahoo.com

***Abstract* – In recent years, it has been observed that many academic programs in Nigerian universities lack the required operational agility and efficiency due to the absence of well domesticated operational planning tools suitable for the prevailing socio-economic and regulatory environment. This study was therefore aimed at developing a generic operations planning model suitable for a typical new post-graduate programme in a Nigerian University. The structure of the University of Ibadan Nigeria's premier and leading university with respect new post graduate programs were studied to gain insight into the system's interactions. A newly introduced Professional Masters of Engineering Management programme was studied to identify key planning decision variables and parameters. Relevant operational data were obtained through observations, interviews and consultations of appropriate university document and literature. Vital planning dimensions adopted include Time, Cost, Revenue, Staffing and Space. Mathematical models and procedures to decide the optimal states or values of these key variables were developed coded for computer implementation. The developed software for these models enables for a changing data base input to solve diverse case scenario.**

***Keywords* – Academic Planning, University Programs, Operational Planning, Mathematical Models.**

I. INTRODUCTION

Improving the quality of education is a challenge concerning many people all around the globe. Many people feel the educational system should provide knowledge, information, and skills that are needed to compete in the world market (Diaz et al 2003). The reality in the Nigerian university system is that there appears to be no proper prior operational plan in place before most academic programs are started. Many of such programs often times are faced with several crises that border on lack of resources, inadequate manpower, low patronage etc. This can be attested to by the recurring sanctions on many existing Postgraduate and Undergraduate programmes by the National University Commission due to poor quality of delivery.

The necessity for sound operational plan cannot be over emphasized. It is however more crucial for an organization starting new programme, services or product to have a plan of operation that fits into the overall strategic interest of the organization. While it is very imperative for manufacturing businesses to have good production plan, Alter (2000) observed that service businesses too, must have a good operations plan to ensure they are effectively managing their activities.

With the combined overarching influences of globalization, liberalization, increasingly more demanding customers' taste, shrinking government funding it is obvious that Nigerian Universities must embrace best practices in their management approach. Beyond just meeting the local statutory requirements for establishing new academic programs university education managers must begin to strive for global excellence by embracing the use of sound IT based decisions support systems to enhance their operational agility and efficiency in the face of stifling competition and shrinking government resources. This paper therefore considers the development of a generic operational planning model suitable for a typical new post-graduate programme in any existing academic department of a Nigerian University.

II. MODEL DEVELOPMENT

Notations: The following notations and terms are adopted for formal model description.

i = index identifying a course
HL = required lecture hours/unit
HP = required practical hours/unit
LUi = Lecture equivalent unit of course i
PUi = Practical equivalent unit of course i
CHi = Contact hour for course i
$LCHi$ = Lecture hours for course i
$PCHi$ = Practical hours for course i
TCH = Total Contact hours
Lw = The average lecture hour taken by each lecturer per week
P = Projected number of applicant students
Q = Number of admitted students which is fraction P
$R1$ = departmental share of form sales
$R2$ = departmental share of tuition fees
$R3$ = practical levies
$R4$ = other charges
r = resource item 1,2,3,4
C= Cost to be incurred for the programme
Mi= Program option/module
Zi= Class Size {equal to the number of students of the respective program module}
Wi= Time in weekly period
Ai= Total available time available in a module per week
Ci= Capacity; maximum number of students in the room
Sp= Space required per student
Ui= Space Utilization
Q = Students' number

III. DATA COLLECTION

Policy and strategic data used for planning items estimations were sourced from curriculum committee's papers, Postgraduate committee documents and senate papers of University of Ibadan, Nigeria oldest and premiere university. Specific operational data were sourced from Curriculum documents related to a newly approved professional Master of Engineering Management in an engineering department of the university.

IV. PLANNING PARAMETERS AND VARIABLES

Interviews of stakeholders in the university were also carried out to identify the most relevant system variables parameters. The following systems parameters and variables were identified by stakeholders to constitute the essentials elements of operations plans of a new academic program.

- Class size
- Staffing
- Standard facilities
- Student-teacher ratio
- Classroom environment
- Space management
- Financial resources
- Program curriculum
- Administration /Management
- Social support centres
- ICT Facilities
- Time management
- Number or applicant students

Among all the aforementioned issues, four key ones were identified as elements of any effective operational plan these are Time, Staffing/Capacity Requirement, Financial Resources allocation, and Space/Facilities.

Therefore the elements of the proposed planning model include determination of Staff and human Capacity requirements, Revenue and cost modeling which deals with cash flow planning, Space and Facility requirement specifications, and Timing plans and Scheduling for contact hours requirements. This is summarized in Fig.1 as Elements of operation planning.

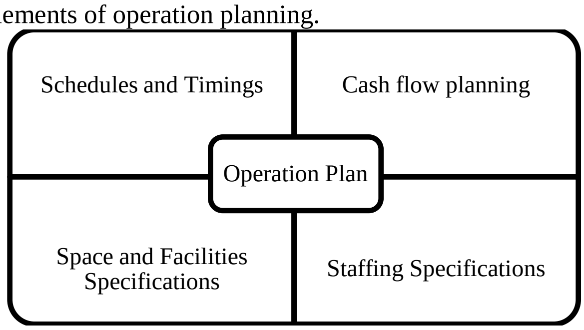

Fig.1. Elements of the Operation Planning model

V. TIME DIMENSION

The operations of a university, being a service system, are heavily rooted in the concept of contact hours. In fact most input variables and outputs characteristics are directly or implicitly linked to the issue of required or delivered contact hours. Most academic institutions approach time in terms of contact hours either by lectures given or practical hours. The total contact hours needed is usually a function of the units of lecture and practical components of various courses undertaken by the students. We have adopted this approach in determination of time and scheduling related decisions.

Effective Contact Hour Determination Modeling

Required Contact hour for each course is dependent on the unit of the course.

Based on the University of Ibadan standard and which is applicable to most other universities in Nigeria the following notations are relevant.

Assumptions

i. Each course has an independent time allocation

ii. The total contact hours comprises of lecture contact hours and practical contact hours

Effective Contact Hour Model Development

$CHi = LCHi + PCHi$……………….................1

But $LCHi = HL \times LUi$ …..................................2

$PCHi = HP \times PUi$…………………………….3

Thus $CHi = (HL \times LUi) + (HP \times PUi)$………......4

$TCH = \sum_{i=1}^{l}(HL \times LUi) + \sum_{i=1}^{p}(HP \times PUi)$…..5

Where l = total number of lecture courses

p = total number of practical courses

$\boldsymbol{TCH = HL\sum_{i=1}^{l} LUi + HP\sum_{i=1}^{p} PUi}$**…............6**

Equation 6 gives the model for calculating the total contact hours for an academic programme.

To calculate the total hours required for each student to graduate, the number of total lecture taken (**l**) and the number of total practical courses (p) will be inputted into the model.

VI. STAFFING/CAPACITY REQUIREMENT MODELING

A training institute might assess its capacity using amount of training per day, number of people trained, classroom space utilized, number of trainers teaching, or a combinations of these.

Determination of Staffing Capacity

For determining the number of lecturers to lecture in the programme;

Assumption

i. All lecturers have even work load of lecture hours

Staffing Capacity Model development

Total lecture hour to be covered per lecturer

$= \sum_{w=1}^{t} Lw$ ………………………………7

Where t = total number of weeks for the programme

Hence number of lecturer = $\boldsymbol{TCH / \sum_{w=1}^{t} L\text{w}}$**……….8**

VII. Cash Flow Planning: Revenue Determination

For effective planning there is a need to be able to project inflow of resources for the programme. The following sources of revenue were identified for most post-graduate programmes in Universities;

Departmental share of

1) Form sales
2) Tuition Fees
3) Practical levies
4) Other charges

Let Xr represent the amount of form, tuition fee, practical fee and other charges and Kr be the departmental share of the form sales and tuition fees

Assumptions

i. Academic programme have more than one source of income

Revenue Model Development

$R1$=$K1\ PX1$……………………………………………9

$R2$ = $K2\ QX2$………………………………………..10

$R3$ = $QX3$……………………………….............11

$R4$ = $QX4$……………………………………………12

$\sum_{r=1}^{4} R_i$ = ($K1\ PX1$) + ($K2\ QX2$) + $QX3$ + $QX4$…....13

If $K1$=$K2$=K

$\sum_{r=1}^{4} Rr$= $\boldsymbol{K}_{\text{r}}$ ($\boldsymbol{PX1}$+ $\boldsymbol{Q}$X2) +$\boldsymbol{Q}\sum_{i=1}^{4} Xr$……………..14

Equation 14 gives the total revenue that can be generated.

VIII. Cash Flow Planning: Cost Determination

The cost elements for many University academic programmes are identified to be

a. Fixed cost {ICT/Facilities Upgrade, Examination/ Administration, Contingencies/Study tour}

b. Honorarium for Lecturers

Assumptions

i. All lecturers have an even average honorarium per contact hour

Let yi represent the amount of those cost elements

Where i = index of costs for the elements

$y1$= ICT/facilities upgrade

$y2$= Examination/Administration

$y3$= Contingencies/Study tour

$y4$= Lecturers' honorarium/hour

Then Total honorarium = Total lecture hours (TCH) × Honorarium per lecturer = TCH × $y4$

$\boldsymbol{C}$= $\sum_{i-1}^{3} yi$+$\boldsymbol{TCHy4}$……………………….……………15

IX. Space/Facility Modeling

Classrooms are a vital component to the University's academic mission. Effective allocation of classroom space for any university programme depends on multiple factors. Key among these are:

- Classroom Space Assignments and Utilization Analyses
- Class Size
- Classroom Space per Station or Seat
- Time Available for lectures
- Different programme options
- Total number of Students

Assumptions

i. Capacity constraint: class/group size cannot exceed room capacity.

ii. No-sharing constraint: at most one class/group is allowed per classroom.

Total number of students = total program module/option (M)× Class size per option(Zi)

Q = $MiZi$…………………………………………..16

Total space capacity = $MiCi$…..............................17

Capacity constraint; $MiZi \leq MiCi$ ……….........18

Otherwise; $Zi \leq Ci$ ………………………………...19

Space required per programme class = $SpZi$ ……..20

Space utilization Ui = Wi/Ai ………………………21

X. Model Applications

For ease of application the computer software for the model was developed using Visual Basic 6.0

The developed planning models are applied to the operation planning of Masters of Engineering Management programme. Projected values of needed parameters and also assumed values in necessary cases are applied to the developed models. From here, projected values for the key planning issues can be calculated.

XI. Results

For the new MEM program the following results were obtained

Time Determination Application

The time determination model is given by the equation below;

$\boldsymbol{TCH}$= $\boldsymbol{HL}\sum_{i=1}^{l} LUi$+$\boldsymbol{HP}\sum_{i=1}^{p} PUi$

For the university of Ibadan academic standards the following holds for model parameterization

1 unit of lecture course is equivalent to 15 contact hours of lectures,

1 unit practical course is equivalent to 45 contact hours of practical

i.e 1 unit ≡ 15 lecture hours

1 unit ≡ 45 practical hours

Hence

Lecture hour/unit *(HL)* = 15

Practical hour/unit *(HP)* = 45

Total lecture units $\sum_{i=1}^{39} LUi$ = 82

Where for the proposed MEM program

Total practical unit $\sum_{i=1}^{7} PUi$ = 7

Total lecture course = 39

Total practical course = 7

TCH_{s}=15(82) + 45(7) = 1,545 Contact Hours

International Journal of Engineering Innovation & Research
Volume 3, Issue 3, ISSN: 2277 – 5668

Total Contact Hour per Student

To get the total contact hour required by a student, we multiply the hour/unit by the minimum unit to be taken by a student For the Masters of Engineering Management programme, the minimum unit to be taken by each student is 45

Thus $TCHs$ = 15(40) + 45(6) =**870** Contact Hours per Student

Total Time Span for programme Completion

Since the programme options are designed to run concurrently, the time span needed to complete the programme will equal the average time needed to complete the compulsory courses and one programme option. This is represented by the Gantt chart below;

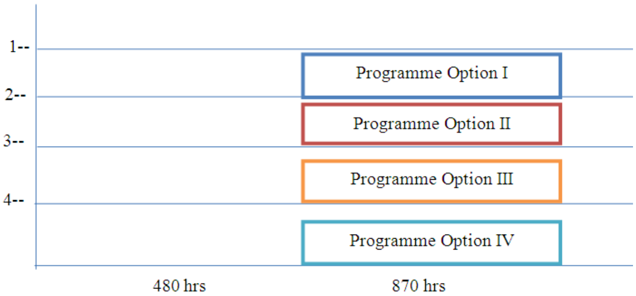

Figure 2 Gantt chart Representation of Time Determination

From all the above computations, the time schedule allocation for the part time, and full time programme plan is given by table 1

Table 1: Time Planning Schedule

	Full Time Module	Part Time Module
Semester Required	3	5
Weeks Required	45	75
Hours Required per Student	870	870
Lecture Hour per Week	19.3	11.6

Staffing/Capacity determination Application

The number of lecturers needed is calculated by the model given below

$TCH/\sum_{w=1}^{t} Lw$

Given TCH=1 545

According to Bekhradnia (2012) the average time to be spent by Lecturer–Student interaction should be approximately 14 hour/week. This gives an average of 2.8 hours/day. In most post graduate programmes, due to the specialization of field, lecturers usually spend this average time per day also in a week

Average hour/lecturer in a week = 2.8 hours/week

Total weeks required = 45weeks ≡ 3 semesters

$\sum_{w=1}^{45} Lw$ = 126

Lecturer number = $1545/126 \cong 12$

Since the programme is speculated to run on 4 different options concurrently:

Total lecturer number = 12×4 = 48

Revenue determination Application

The revenue determination model is given below

$\sum_{i=1}^{4} Ri = K\ (PX1 + QX2) + Q\sum_{i=3}^{4} Xi$

Revenues Parameters

The estimated amount of identified revenue items are given below

$x1$ = amount of form sales = 18,000

$x2$ = amount of tuition fees = 150,000

$x3$ = practical levies for the department = 15,000

$x4$ = other charges = 1,000

Assume departmental share of form sales and tuition (K) = 0.4

Revenue estimates inputs

P = number of applicants students

Q = fraction of P i.e number of admitted students

$\sum_{i=1}^{4} Ri$= 0.4(18 000P+150 000Q) + Q (15 000+1 000)

$\sum_{i=1}^{4} Ri$=7,200P + 60000Q+16000Q

$\boldsymbol{\sum_{i=1}^{4} Ri = 7,2000P + 76,000Q}$

Cost Determination Application

The cost determination model is given by the equation below

$C = \sum_{i=1}^{3} yi + TCHy4$

Cost Parameters

The projected amount of identified cost items are given below

$y1$ = ICT/Facilities upgrade = 500,000

$y2$ = Examination/Administration = 200,000

$y3$ = Contingencies/Study tour = 200,000

Cost Variables

$y4$ = Honorarium for lecturers/contact hour

C=500 000+200 000+200 000+$TCHy4$

$\boldsymbol{C = 900000 + TCHy4}$

For optimality;

$\boldsymbol{\sum_{i=1}^{4} Ri \geq \sum_{i=1}^{2} Ci}$

i.e $\boldsymbol{7200P + 76000Q \geq 900000 + TCHy4}$

XII. Cost-Revenue Breakeven Analysis

From the revenue equation $\boldsymbol{\sum_{i=1}^{4} Ri = 7,200P + 76}$, It is given that Q *(number of admitted students)* should be a fraction of *P (number of applicant students)*. Hence the maximum number of Q possible will be 100%P

Also from the cost equation $\boldsymbol{C = 1100000 + TCHy5.}$ Assume that $y5$(Honorarium per contact hour = **3,000**) and already calculated total contact hour is 1,545 Hours.

$\boldsymbol{C = 5735000}$

To get the break-even analysis, we assume 100% of $PisQ$ thus the number of students is varied from 20 to 200 to get the point where the revenue generated will equal the cost. This is shown in Fig. 3.

From this graph, it is seen that if all applicants' students are admitted, the breakeven point is at 70 students but this is not always the case because if there are more applicants students it will not be feasible admitting all of them. This will lead to the development of sensitivity analysis which will give how $PandQ$ should vary based on the total fixed cost.

International Journal of Engineering Innovation & Research
Volume 3, Issue 3, ISSN: 2277 – 5668

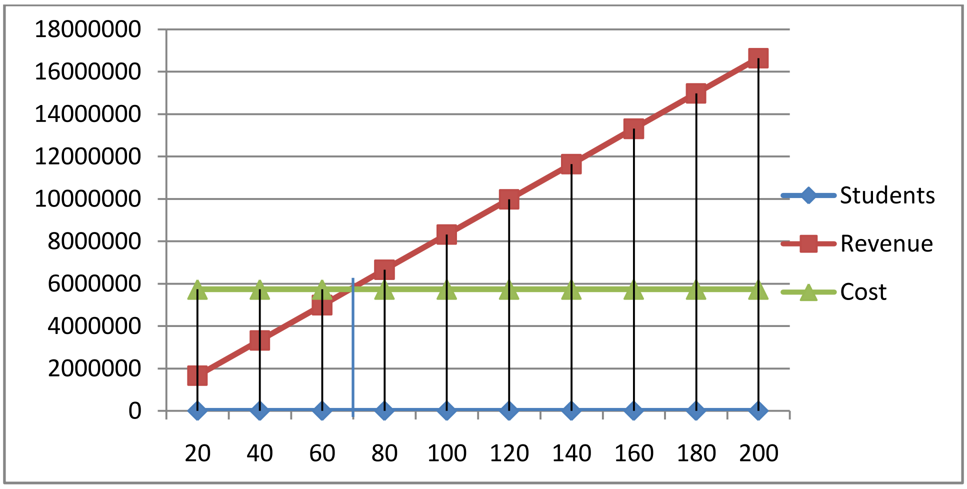

Fig.3. Graph of Break-Even Analysis

XIII. Sensitivity Analysis

Equating the revenue equation to the total cost, i.e
$\mathbf{7{,}200P + 76{,}000Q} = \mathbf{5735000}$

Now let Q be equal to xP where x is the percentage fraction of P

Substituting $Q = xP\{\mathbf{7,2000P+76,000xP = 5735000}\}$

Since the least number of students that must be admitted is 70 from the breakeven analysis, we vary the number of student from 70 to 200 to know the least percentage of P that Q must be to still make sure that the required cost is being met.

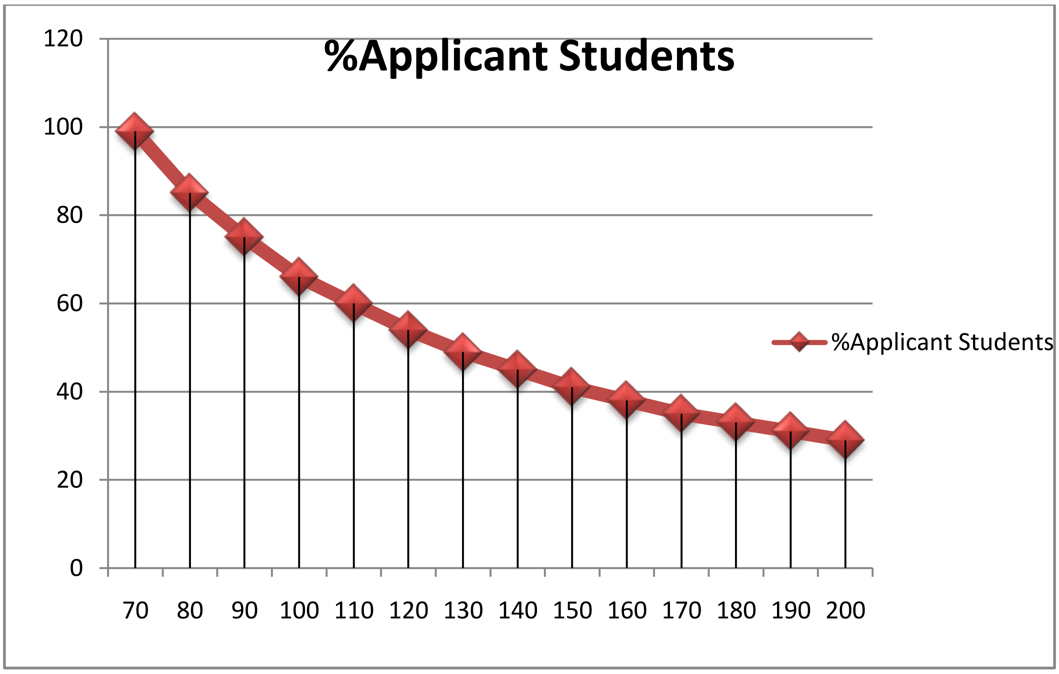

Fig.4. Graph of Sensitivity Analysis

Space/Facility Model Application

Total space capacity is given by the formular $MiCi$
Given that the programme option/module = 4

For efficient delivery of lectures, 4 classrooms have to be provided to with each class space given by equation 20
$Ci = SpZi$
Where Ci = Class capacity
Sp = Space per Student
Zi = Number of Student in a Class/Programme/Option

XIV. Conclusions

In this paper, it has been established that a structured Organization, be it Business, School etc has to be guided by workable operations plan for its daily, weekly, monthly and yearly operations for it to maintain its performance over an appreciable period of time. In the case of the academic programme considered, the developed planning tools/models developed when applied to the Masters of Engineering programme gave the result that result that the programme will run for 1,545 contact hours. Based on the requirement to finish the course, 870 hours will be needed by each student. The number of lecturers needed was calculated not to be less than 48. The revenue and cost model made use of the projected values of the parameters in the equations.

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AUTHOR’S PROFILE

I. S. Oladeji

Oladeji was born on the 16th November, 1984. A native of Oyo State, Nigeria. He had his first degree in Chemical Engr from LadokeAkintola University, Nigeria, and MSc Degree in Industrial Engr from University of Ibadan. He is presently working with a Waste Management Company in Port- Harcourt, Nigeria.

V. O. Oladokun

Oladokun is a native of Oyo State, Nigeria. A graduate of Mechanical Engr from ObafemiAwolowo University, Osun State. He had his second degree in Industrial Engr from University of Ibadan and further to proceed to his PhD from the same institution. He is presently a senior lecturer in University of Ibadan.