Mathematical Model for Optimal Assignment of Credits to Different Degree Programs: A case of Mwenge Catholic University, Faculty of Humanities and Business Studies (FoHBS)

Annord Mwapinga

Department of Natural Sciences and Information Technology
Mwenge Catholic University, P.O. Box 1226 Moshi-Tanzania
Email: annord.mwapinga@mwecau.ac.tz

Abstract. The mathematical model for optimal that determines the optimal allocation of credits at Mwenge Catholic University, Faculty of Humanities and Business Studies has been formulated using the five different programs. The POM-QM for Windows software has been used to determine the optimal allocation of credits. The study found that the optimal allocation of credits has an alternative optimal solution. The study has found that all courses (except GST 101, Basic Computer Application) should be assigned 9 credits. The course GST 101 should be assigned 6 credits and should be offered to the entire faculty by Bachelor of Arts in Geography and Environmental Studies.

List of abbreviations

BAED	Bachelor of Arts with Education
BPE	Bachelor of Arts in Philosophy with Ethics
BAGEN	Bachelor of Arts in Geography and Environmental Studies
BSSW	Bachelor of Arts in Sociology and Social Work
BAF	Bachelor of Accounting and Finance

1. Introduction

The Faculty of Humanities and Business Studies (FoHBS) is one of the faculties at Mwenge Catholic University (MWECAU) that offers different programs to undergraduate and postgraduate students. The faculty offers some common courses in different degree programs, and every candidate joining the university has to study the common courses for him or her to graduate. Common courses are very important in any university as they may help to make the university unique, and depending on the nature of the common courses, they can be useful to students after the successful completion of their studies.

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The Tanzania Commission for Universities (TCU) directs all universities to assign credit values for every course or subject the candidate learns at the university. The credit value refers to the measurement unit for the notional or average learning time of the candidates in the respective course. Currently, 1 credit value equals 10 hours of learning.

In assigning credit values, the FoHBS has managed to assign credits on all common courses as expected. However, the common courses with the same course content are assigned different credit values in different programs. It has been observed that every degree program can assign different credits despite the fact that the course contents are the same. This implies that the same course with the same course contents can have content of a different learning time. In this regard, the current work aims at formulating a mathematical model such that its solution gives an optimal way of assigning credits to the five selected degree programs. The current assignment assigns one program to offer one common course.

Table 1: Current assignment of credit values in FoHBS

Program/Course	GST 101	GST 102	GST 201	GST 202	GST 301
BAED	9	9	10	10	10
BPE	9	9	9	10	9
BAGEN	6	6	6	6	6
BASSW	10	10	10	9	9
BAF	9	9	9	9	9

Several scholars have worked on assignment problems; according to [1], the assignment problem is one of the main problems while assigning tasks to the worker. It is one of the fundamental combinatorial optimization problems in the branch of optimization or operation research in mathematics. It is one of the special cases of transportation problems. It is also explained by [2] that the assignment problem is a transportation problem where the number of jobs (or origins or sources) and the number of facilities (or destination, machines, people, and so on) are equal. It arises as a result of different decision-making situations relating to jobs or task assignments in day-to-day activities.

Problems related to assignment arise in a range of fields, for example, healthcare, transportation, education, and sports. In fact, this is a well-studied topic in combinatorial optimization problems under the optimization or operations research branches [3]. The assignment problem is used worldwide to solve real-world problems. An assignment problem plays an important role in industry and other applications [4].

Besides, [5] points out that an important topic, put forward immediately after the transportation problem, is the assignment problem. This is particularly important in the theory of decision-making. Other scholars who have worked on assignment problems include [6] and [7].

Furthermore, [8] and [9] worked on optimization problems by formulating and solving normal transportation problems.

The current study formulates and solves the model to find the optimal way of assigning the credits. In this regard, one program is expected to handle one course for the entire faculty. The optimal assignment will bring more efficiency and reduce some hours that get wasted unnecessarily.

2. Mathematical formulation

In this part, we mathematically form the mathematical model. We assume that the problem is of transportation with demand and supply equal to 1. Furthermore, it is assumed that the problem is balanced. The current credits are considered to be the costs involved. the following variables are introduced

x_{11} is the optimal credit value for GST 101 assigned to BAED
x_{12} is the optimal credit value for GST 102 assigned to BAED
x_{13} is the optimal credit value for GST 201 assigned to BAED
x_{14} is the optimal credit value for GST 202 assigned to BAED
x_{15} is the optimal credit value for GST 301 assigned to BAED
x_{21} is the optimal credit value for GST 101 assigned to BPE
x_{22} is the optimal credit value for GST 102 assigned to BPE
x_{23} is the optimal credit value for GST 201 assigned to BPE
x_{24} is the optimal credit value for GST 202 assigned to BPE
x_{25} is the optimal credit value for GST 301 assigned to BPE
x_{31} is the optimal credit value for GST 101 assigned to BAGEN
x_{32} is the optimal credit value for GST 102 assigned to BAGEN
x_{33} is the optimal credit value for GST 201 assigned to BAGEN
x_{34} is the optimal credit value for GST 202 assigned to BAGEN
x_{35} is the optimal credit value for GST 301 assigned to BAGEN
x_{41} is the optimal credit value for GST 101 assigned to BASSW
x_{42} is the optimal credit value for GST 102 assigned to BASSW
x_{43} is the optimal credit value for GST 201 assigned to BASSW
x_{44} is the optimal credit value for GST 202 assigned to BASSW
x_{45} is the optimal credit value for GST 301 assigned to BASSW
x_{51} is the optimal credit value for GST 101 assigned to BAF
x_{52} is the optimal credit value for GST 102 assigned to BAF
x_{53} is the optimal credit value for GST 201 assigned to BAF
x_{54} is the optimal credit value for GST 202 assigned to BAF
x_{55} is the optimal credit value for GST 301 assigned to BAF

Since demand and supply are considered to be 1, then the model is as shown hereunder. The objective is to minimize the function

$$
\begin{aligned}
F = {} & x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{21} + x_{22} + x_{23} + x_{24} + x_{25} \\
& + x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{41} + x_{42} + x_{43} + x_{44} + x_{45} \\
& + x_{51} + x_{52} + x_{53} + x_{54} + x_{55} + x_{11} + x_{21} + x_{31} + x_{41} + x_{51} \\
& + x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + x_{13} + x_{23} + x_{33} + x_{43} + x_{53} \\
& + x_{14} + x_{24} + x_{34} + x_{44} + x_{54} + x_{15} + x_{25} + x_{35} + x_{45} + x_{55}
\end{aligned}
\tag{2.1}
$$

Subject to

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} = 1 \tag{2.2}$$
$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} = 1 \tag{2.3}$$

$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} = 1 \qquad (2.4)$$
$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} = 1 \qquad (2.5)$$
$$x_{51} + x_{52} + x_{53} + x_{54} + x_{55} = 1 \qquad (2.6)$$
$$x_{11} + x_{21} + x_{31} + x_{41} + x_{51} = 1 \qquad (2.7)$$
$$x_{12} + x_{22} + x_{32} + x_{42} + x_{52} = 1 \qquad (2.8)$$
$$x_{13} + x_{23} + x_{33} + x_{43} + x_{53} = 1 \qquad (2.9)$$
$$x_{14} + x_{24} + x_{34} + x_{44} + x_{54} = 1 \qquad (2.10)$$
$$x_{15} + x_{25} + x_{35} + x_{45} + x_{55} = 1 \qquad (2.11)$$

$$x_{ij} \geq 0, \qquad i = 1, 2, \ldots, 5 \qquad j = 1, 2, \ldots, 5 \qquad (2.12)$$

We write the model above in short form as follows

$$\text{Minimize } z = \sum_{i=1}^{5} \sum_{j=1}^{5} c_{ij} x_{ij} \qquad (2.13)$$

Subject to

$$\sum_{i=1}^{5} x_{ij} = 1 \ , \quad i = 1, \ldots, 5 \qquad (2.14)$$

$$\sum_{j=1}^{5} x_{ij} = 1 \ , \quad j = 1, \ldots, 5 \qquad (2.15)$$

$$x_{ij} \geq 0 \qquad (2.16)$$

$$x_{ij} = \begin{cases} 1 \text{ if program } i \text{ is assigned to deliver a common course } j \\ 0 \text{ if program } i \text{ is not assigned to deliver a common course } j \end{cases}$$

3. Method of solution

The mathematical solution of the model formulated was solved using POM-QM for Windows.

Table 2 below shows the results of the optimal allocation of the credits. It is shown that, the program of Bachelor of Arts with Education (BAED) should be assigned to facilitate or deliverGST 101 (Communication Skills), Bachelor of Philosophy with Ethics should be assigned GST 201 (development studies), Bachelor of Arts in Geography and Environmental Studies should be assigned GST 101 (Basic Computer Application), Bachelor of Arts in Sociology and SocialWork should be assigned GST 202 (Social and

Professional Ethics) and Bachelor of Accounting and Finance should be assigned GST 301 (Entrepreneurship). Besides, Table 2 below shows the same with iterations. Iteration 2 gives an optimal assignment.

Optimal Allocation of Credits Faculty of Humanities and Business					
Optimal Cost=$42	GST 101	GST 102	GST 201	GST 202	GST 301
BAED		1			
BPE			1		0
BAGEN	1	0	0		
BSSW				1	0
BAF					1

Table 2: Optimal allocation of credits

	GST 101	GST 102	GST 201	GST 202	GST 301
Iteration 1					
BAED	(0)	1	(0)	(0)	(0)
BPE	(1)	(1)	1	(1)	(0)
BAGEN	1	(0)	(-1)	(-1)	(-1)
BSSW	(2)	(2)	(1)	1	(0)
BAF	(1)	(1)	(0)	(0)	1
Iteration 2					
BAED	(0)	1	(1)	(1)	(1)
BPE	(0)	(0)	1	(1)	(0)
BAGEN	1	(0)	(0)	(0)	(0)
BSSW	(1)	(1)	(1)	1	(0)
BAF	(0)	(0)	(0)	(0)	1

Table 3: Optimal allocation of credits with its iterations

An interesting finding is observed in Table 4, where the solution shows that there is an alternative optimal solution, where GST can be assigned 9 credits in the program of Bachelor of Arts withEducation or Bachelor of Philosophy with Ethics. The table shows further that GST 101 should have 6 credits that will be offered by the program of Bachelor of Arts in Geography and Environmental Studies. GST 102 should have 9 credits and should be offered in the faculty by the program of Bachelor of Arts with Education. GST 201 should be assigned 9 credits and shouldbe offered within the entire faculty by the program of Bachelor of Philosophy with Ethics. It is further shown that the course GST 202 should be assigned 9 credits and should be offered by the program of Bachelor of Arts in Sociology and Social Work. The GST 301 is suggested to be assigned 9 credits and should be handled by the program of Bachelor of Accounting and Finance.

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Optimal Allocation of Credits Faculty of Humanities and Business				
From	To	Shipment	Cost per	Shipment
BAED	GST 102	1	9	9
PBE	GST 201	1	9	9
PBE	GST 301	0	9	0
BAGEN	GST 101	1	6	6
BAGEN	GST 102	0	6	0
BAGEN	GST 201	0	6	0
BSSW	GST 202	1	9	9
BSSW	GST 301	0	9	0
BAF	GST 301	1	9	9

Table 4: Optimal number of credits

4. Conclusion

The study finds the optimal allocation of learning hours for common five courses in different programs at Mwenge Catholic University in the Faculty of Humanities and Business Studies. The optimal results show how the credits should be allocated in the programs. Every programis therefore assigned to deliver or offer one course at an optimal number of credits.

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