Multiobjective Zero One faculty Course Assignment Problem Solution Using Weight Function

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Abstract- *The faculty course assignment problem is a difficult optimization problem with real world applications. The multiobjective zero one linear programming model is developed by considering both faculty preferences and administrator preferences which includes case studies. It is very difficult to solve such problems in tasks due to size and conflicting objectives of the problems. This paper gives a general Mathematical Model for Faculty Course Assigning (MMFCA) problem with result of each course given to faculty by administrator's as a result preference for a better solution. Due to this multiobjective zero-one linear programming model become more nonconvex. The simple weights are used in different scalarization to remove nonconvexity and to give optimum solution.*

Keywords- Preference based decision making approach, Faculty course assignment problem, Zero–one multiobjective programming, Scalarization.

I. INTRODUCTION

Now a day it is observed that the employee assignment problem has become more intricate. Particularly schools, colleges, industries, organizations, etc are facing scheduling problem for assigning tasks. For example, scheduling or assigning work means matching people, places, time slots, and facilities. Further, it is very difficult to solve problems having so many constraints. Generally, the constraints are of two types, to be precise - hard and soft. All constraints must satisfy to get optimum solution. To solve employee assignment problem, we need to check 0–1 discreteness of the given problem which are known as non-deterministic polynomial (NP) -hard. This model corresponds to some situations which occur frequently in the basic training programs of universities and schools. It has been shown that this problem is NP complete when found in some sufficient conditions for the existence of a timetable. In many cases, it may be difficult to even find a feasible point. Consequently, these problems have also been considered within different decomposition forms such as class teacher timetabling and faculty course slot assignments to name few.

The problem of faculty course assignment satisfy all the constraints like one subject to one teacher only, teacher preference to teach course, not exceeding loud, all courses are distributed according to preferences of teachers as well as administratively. So many researchers have carried out research in the field of assigning courses to faculty. The timetable construction bibliography was given by Schmidt and Strohlein [2]. Timetable or Scheduling problem with different heuristic techniques such as tabu search, genetic algorithms and expert systems were examined by Costa [4], Erben and Keppler [6], Guyette et al. [5] and Hertz [3]. Two-stage optimization model maximize faculty course preferences in assigning faculty members to courses (stage 1) and then maximize faculty time preferences by allocating courses to time blocks (stage 2). These constraints, which are computationally more complex than the others, are recovered during the second stage, and a number of sub-problems, one for each day of the week were solved for local optima by Badri [7]. Bloomfield and McShary [1] also considered faculty preferences in their heuristic approach. Kara and Ozdemir [8] developed a minimax approach to the faculty course assignment problem by considering faculty preferences. Asratian and Werra [13] considered a theoretical model which extends the basic class teacher model of timetabling. This model corresponds to some situations which occur frequently in the basic training programs of universities and schools. It has been shown that this problem is NP complete when founded in some sufficient conditions for the existence of a timetable. Kara and Ozdemir presented a min–max approach to the faculty course assignment problem by considering faculty preferences. This study is a continuation and a generalization of the faculty–course assignment problem considered earlier by Ozdemir and Gasimov [14]. They constructed a multi objective 0-1 nonlinear model of the problem, considering participants' average preferences and explained an effective way for its solution.

Most research done so far on the problem has dealt with quantitative objective functions. When there are several such functions, one had to combine them into a single objective function by assuming that they are measured on the same known scale. By transforming multiple objectives into a single objective, one needs to ensure that the problem with a single objective yields all solutions to the initial multiobjective problem. Such situation strongly depends on the properties of the problem and on how to combine the functions into a single one. Not all method for combining multiple objectives into a single objective gives the desired results. In this paper, we will use a method developed by the M. Koksaln, S. Zionts (Eds.) [11] with a special class of functions that can be used to successfully combine multiple objectives. This method provides necessary and sufficient conditions for efficient solutions of nonconvex multiobjective optimization problems. It makes it possible for one to obtain optimal solutions to multiobjective problems without convexity and differentiability assumptions. The next step is to solve the scalarized problem obtained by combining multiple objectives. Scalarization changes only the multiobjective nature of the problem but preserves nonconvexity, non-differentiability and 0–1 discreteness of the variables. In general, methods for solving constrained optimization problems are based on transforming a constrained optimization problem to an unconstrained one, called the dual problem. The difficulty arises with nonconvexity, tackled for example by Rockafellar and Wets [9] and Azimov and Gasimov [10]. The dual problem with respect to the sharp augmented Lagrangian and nondifferentiable optimization method in nonconvex programming by R. N. Gasimov [12]. He then developed a modified sub gradient and cutting plane method that is applicable to nonconvex and non-smooth optimization problems. In contrast with other sub gradient methods, he provided a constructive method for the calculation of step size parameters. The sub gradient of the dual function is calculated explicitly and used along with the step size parameters to speed up the convergence of the sequence of values of the dual function to the optimum value.

In this paper, we consider a general faculty course assignment problem with qualitative and quantitative multiple objectives and its special version as a real example and give a methodology for finding non-dominated solutions. A major question that arises is how to formulate objective functions that involve qualitative preferences such as satisfaction level and how to combine these functions into a single function to make the optimal assignment. Note that the administration's and faculty preferences in specific courses and time slot assignments are important considerations. By considering these preferences, participants would be encouraged, and this would also affect the students' performances during the lectures. As a result, the overall performance of the educational system is likely to increase. We develop a linear 0-1 multiobjective model for this problem in which objective functions related to the administration's total preferences on instructor–course slot assignments, and the faculty total preferences on instructor–course slot assignments would be maximized simultaneously. Besides, the model also includes the administration's objective functions to minimize the total deviation from the faculty upper load limits. To demonstrate the features of our model, a special example has been constructed. The solution process of this problem has been considered in two stages: scalarization of the given problem and solving the scalarized problem. Because of the 0-1 nature of the problem, a special scalarization approach called conic scalarization is applied. In order to reduce or solve the scalarized problem, we need meaningful weights for each objective on the one hand, and because of the similarity between the properties of some objectives we also need to combine objectives into groups on the other hand. Efficient solution corresponding to given sets of weights has been calculated. LINGO 17.0 solver was used to solve the scalarized problem.

The outline for the paper is as follows. In Section 2 we construct the mathematical model of the faculty-course assignment problem. In Section 3 provide steps to solve mathematical model. Section 4 is the case study to solve 6 faculty and 15 courses assigning problem. To solve faculty-course assignment we take preference of faculty, faculty results for each courses and administrative preferences. Using the weight function and different value of α chosen we get optimum value of course assigning of the faculty. In Section 5 results are discussed which is followed by conclusion at the end.

II. PROBLEM FORMULATION

The mathematical model involves faculty-courses assigning in a single stage. As competition increases in educational system, it is necessary to change timetable so as to maintain quality teaching for the students. In many educational institutes faculty are recent or tenured. The problem arises due to less results in final examination by the students for specific subjects. Administrator's decided to change course preferences and give according to results preferences to increase results of each subject/courses. The model described here involves assigning courses to faculty. Its parameters, decision variables, constraints and the objectives are defined as follows:

A. Model Parameters

Courses I = {1, 2, 3, ..., m}; I = ∪Ij, Ij is the set of courses that faculty j can take;
Faculty J = {1, 2, 3, …, n} = Jo ∪Jn for all k < n;
where Jo = {1, 2, …, k} tenured faculty and Jn = {k+1, k+2, ..., n} recent faculty;
hi: total number of lecture hours for the ith course in a week;
lj and uj: lower and upper bounds for the jth faculty's weekly load;
tij: preference level of the ith course by the jth faculty (tij≥1, 1 indicates the most desired course);
aij: administrative preference level for the assignment of the ith course to the jth faculty;
bij: other preference level for the assignment of the ith course to the jth faculty;

B. Model Decision Variables

In this model the decision variable xij represents the assignment of a course to faculty and is defined as follows

$$x_{ij} = \begin{cases} 1, \text{if course i is assigned to faculty j} \\ \quad 0, \text{otherwise} \end{cases}$$

C. Model Constraints

Each course must be assigned to only one faculty: Equation (2.1) assure that a faculty-course combination is not split. In other words, since each faculty and administrator were given the opportunity to provide their preferences for each course, these constraints assure that only one of these preferences is selected for each faculty-course assigning. The number of these constraints will equal the number of faculty-course being offered.

$$\sum_{j=1}^{n} x_{ij} = 1, \quad i = 1, 2, 3, \ldots, \mathrm{m} \qquad (2.1)$$

The weekly load of each faculty must be between his/her lower and upper limits: Equation (2.2) do allocation of each faculty according to their load given. In other words, courses are assigned by calculating their lower as well as upper bound of their load limit. It is also assured that load is distributed or assign not only by preferences but also by their load capacity.

$$l_j \leq \sum_{i=1}^{m} x_{ij} h_i \leq u_j, \; j = 1,2,3, \ldots, n \qquad (2.2)$$

The last constraint $g_t(x) \leq 0, t = 1, 2, \ldots, r$ is used to transform the 0-1 variables to continuous ones.

D. Model Objectives

Mathematical Model of the Faculty Course Assignment Problem (MMFCAP) can be calculated as follows:
L_k is the average preference
level of faculty per hour taught: Equation (2.3) is to calculate each faculty course assigning by their preference given. The courses assign is to be satisfied to ensure that faculty members get their required load of all courses.

$$L_k(x) = \frac{\sum_{i=1}^{m} x_{ij} h_i t_{ij}}{\sum_{i=1}^{m} x_{ij} h_i}, k = 1,2, \ldots, l$$
$$\text{and } j = 1,2, \ldots, n \qquad (2.3)$$

Minimize the average preference level of all faculty: Equation (2.4) minimize the average of all faculty preference level to assign the courses. Taking averages of each faculty priorities of preference are almost satisfied.

$$A_1(x) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} h_i t_{ij}}{\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} h_i} \qquad (2.4)$$

Minimize the administrator's total preference level: Equation (2.5) assign courses to faculty by best choice from faculty as well as administrator preference level.

$$A_2(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} a_{ij} x_{ij} \qquad (2.5)$$

Minimize the total deviation from the upper load limits of the faculty: Equation (2.6) manage load of each faculty. Otherwise all course can be assign to one faculty or some faculty are not assign any courses. So, it helps to assign course equally and according to preference given for assigning courses.

$$A_3(x) = \sum_{j \in J_n} \left(u_j - \sum_{i=1}^{m} x_{ij} h_i \right) \qquad (2.6)$$

Minimize the others preference level: Equation (2.7) is also one of the administrator preferences like result analysis of faculty-courses, student preference level etc for assigning faculty-courses.

$$A_k(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} b_{ij} x_{ij}, \text{where } k = 4,5, \ldots, p \qquad (2.7)$$

The multi-objective mathematical model of the faculty course assignment problem: Here above objectives are classified into two group. First group for the faculty L_1(x),

$L_2(x), \ldots, L_l(x)$ and second group for administrator $A_1(x)$, $A_2(x)$, …, $A_p(x)$. Thus, the multiobjective MMFCAP can be formulated as follows:

minimize $[L_1(x), L_2(x), \ldots, L_l(x), A_1(x), A_2(x), \ldots, A_p(x)]$
subject to equation (2.1) to equation (2.2).

General form of the multi-objective mathematical model of the faculty course assignment problem:

minimize $[f_1(x), f_2(x), \ldots, f_n(x)]$
subject to $x \in X_0 = \{x \in X: g_t(x) \leq 0, t = 1, 2, \ldots, r\}$
where $f_k(x) = L_k(x); k = 1, 2, \ldots, l$
$f_k(x) = A_v(x); k = l, l+1, \ldots, n$ and $v = 1, 2, \ldots, p$

Objective of generalised form of the multi-objectivemathematical model:

$$f(x) = \sum_{i=1}^{n} w_i f_i(x) + \alpha \sum_{i=1}^{n} |f_i(x)| \quad (2.8)$$

where w_i is the weight function and the model tell us to choose αsuch that $0 < \alpha < \min(w_i)$.

III. STEPS OF THE MODEL

Operation research is basically used to solve organization problems which arise in educational institute as well as industries like transportation, assignment, replacement theory, construction projects, inventory management etc. Faculty-course assigning problem is well structured and to fit the model for the same was relatively easy. Important features of operation research are decision making, scientific approach, objective, inter disciplinary team approach and finally use of computers to solve more complex problems. Using mathematical modelling decision makers can take more effective and efficient decision even in very complex set of constraints. The step-wise description of the proposed model with following aspects of decision making;

Step-1 Read the real-world problem of assigning faculty-course problem.
Step-2 Develop mathematical model for faculty course assigning (MMFCA) problem.
Step-3 Convert multiobjective assignment problem into single objective optimization problem.
Step-4 Solve single objective optimization problem using fuzzy weight and α level.
Step-5 Model decision variables gives assigning of course to faculty if its value is 1.
Step-6 If value is not 1 then go to step 4 for feasible solution by changing α level.

Flow chart for Mathematical Model for Faculty Courses Assigning (MMFCA)

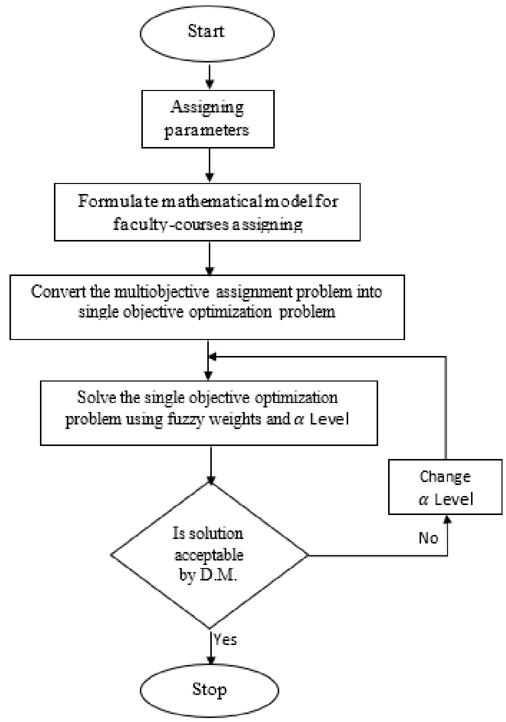


Figure 1: Flowchart for Mathematical Model for Faculty Courses Assigning (MMFCA)

IV. CASE STUDY

Our work on this paper was motivated by a real need in our Department of Mathematics, Uka Tarsadia University(UTU), Bardoli. Department of Mathematics had to assign courses to faculty such that all the preferences are satisfied. These steps have been applied to the particular case of Mathematics Department of UTU, Bardoli by considering 6 faculty and 15 courses. Each faculty may or may not be able to give all the courses considered.

$I_j \subseteq I$ is the set of indices showing the courses that faculty j is able to give, j = 1, 2, 3, 4, 5, 6;
P_k is the set of courses desirable to give at the k^{th} preference level; in this example we assume that k = 1, 2, 3, 4;
h_i: total number of lecture hours for the i^{th} course in a week.
l_j, u_j: lower and upper bounds respectively on the j^{th} faculty weekly load;
t_{ij}: preference level of the i^{th} course by the j^{th} faculty ($t_{ij} \geq 1$, 1 indicates the most desired course);
a_{ij}: administrative preference level for the assignment of the i^{th} course by the j^{th} faculty.
b_{ij}: previous result of the i^{th} course by the j^{th} faculty for the assigning.

The administration has some preferences in assigning courses to faculty and the faculty in turn also have preferences for these courses according to their previous result analysis. The preferences are given in tables 1, 2 and 3. Table 1 contains the value of t_{ij}, for example the number 5 in the first row under P_1 indicates that t_{51} = 1. The numbers 2, 3 in the first row under P_2 indicate that $t_{21} = t_{31} = 2$. The first row of table 4 gives the course number and the second row the number of hours required to teach that course. The first row of table 5 indicates the faculty, the second (third) row gives the upper (lower) limit on the number of hours each instructor can teach in a week.

Table 1: Faculty preference and courses

(j)	I_j; Preferred courses by the faculty	The list of un-preferred courses	P_1	P_2	P_3	P_4
1	1,2,3,4,5	---	5	2,3	4	1
2	1,2,3,6,7,8,9,10	9	6	10	7, 8	1,2, 3
3	6,7,11,12,13,14,15	6,7,14	15	11	13	12
4	1,2,3,10	1,2	--	3	10	--
5	11,12,13,14,15	11,12,13	--	14,15	--	--
6	8,9,11,12,13,14	11,12,14	8, 9	13	--	--

Table 2: Administration preferences

Courses(I_j)	Faculty (j)					
	1	2	3	4	5	6
1,2	1	4	---	4	---	---
3	1000	4	---	1	---	---
4,5	1	---	---	---	---	---
6,7	---	1	4	---	---	---
8	---	1	---	---	---	2
9	---	1000	---	---	---	1
10	---	1000	---	1	---	---
11,12,13	---	---	1	---	4	4
14	---	---	1000	---	1	1000
15	---	---	1000	---	1	---

Table 3: Faculty course result analysis

Courses (I_j)	Faculty(j) result analysis					
	1	2	3	4	5	6
1	0.7	0.4	--	0.5	--	--
2	0.5	0.3	--	0.3	--	--
3	0.3	0.4	--	0.1	--	--
4	0.1	--	--	--	--	--
5	0.2	--	--	--	--	--
6	--	0.3	0.5	--	--	--
7	--	0.5	0.4	--	--	--
8	--	0.2	--	--	--	0.2
9	--	0.5	--	--	--	0.1
10	--	0.4	--	0.2	--	--
11	--	--	0.2	--	0.1	0.3
12	--	--	0.1	--	0.2	0.4
13	--	--	0.2	--	0.4	0.1
14	--	--	0.4	--	0.2	0.5
15	--	--	0.5	--	0.3	--

In table 2:
a_{ij} = 1, 2, 3, 4, 1000 if the administrators like the faculty to give the course less and less in increasing order of the value.
a_{ij} = -- if the faculty cannot give the course.
In table 3:
b_{ij} = 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 obtained values by minimizing the result analysis of the faculty to give the course.b_{ij} = -- if the faculty have not taught courses.

Table 4: Weekly lecture hours of courses

Courses(i)	1,2,3	4,5	6,7,10,11,12,13,14,15	8,9
Hours(h_i)	3	2	4	6

Table 5: Upper and Lower bounds on weekly loads for instructors

Faculty (j)	1	2	3	4	5	6
Upper bound (u_j)	15	25	20	6	15	20
Lower bound (l_j)	3	8	8	0	3	8

We have ten objectives to satisfy in this particular problem. They are minimized for each of six faculty.

The average preference level L_j per hour taught:

$$L_j(x) = \frac{\sum_{i=1}^{15} x_{ij} h_i t_{ij}}{\sum_{i=1}^{15} x_{ij} h_i}, j = 1, 2, \dots, 6 \qquad (3.1)$$

Minimize the average preference level of all faculty:

$$A_1(x) = \frac{\sum_{i=1}^{15} \sum_{j=1}^{6} x_{ij} h_i t_{ij}}{\sum_{i=1}^{15} \sum_{j=1}^{6} x_{ij} h_i}, \qquad (3.2)$$

Minimize the administration's total preference level:

$$A_2(x) = \sum_{i=1}^{15}\sum_{j=1}^{6} a_{ij}x_{ij} \quad (3.3)$$

Minimize the total deviation from the upper load limits of the faculty:

$$A_3(x) = \sum_{j\in J_n}\left(u_j - \sum_{i=1}^{15} x_{ij}h_i\right) \quad (3.4)$$

Minimize the faculty result analysis for each course:

$$A_4(x) = \sum_{i=1}^{15}\sum_{j=1}^{6} b_{ij}x_{ij} \quad (3.5)$$

Our multi-objectives mathematical model now has the form

Minimize [$L_1(x)$, $L_2(x)$, $L_3(x)$, $L_4(x)$, $L_5(x)$, $L_6(x)$, $A_1(x)$, $A_2(x)$, $A_3(x)$, $A_4(x)$]

Subject to

$$\sum_{j=1}^{6} x_{ij} = 1, \qquad i = 1,2,3,\dots,15. \qquad (3.6)$$

$$l_j \le \sum_{i=1}^{15} x_{ij}h_i \le u_j, \quad j = 1,2,\dots,6. \qquad (3.7)$$

For computational simplicity we have used slack variables $y_1, y_2, \dots, y_{12}$ in our solution. The slack variables are needed to reduce the inequalities in (3.7) to equalities. Thus, we can write all constraints as follows:

$g_1(x) = x_{11}+x_{12}+x_{14} - 1 = 0,$
$g_2(x) = x_{21}+x_{22}+x_{24} - 1 = 0,$
$g_3(x) = x_{31}+x_{32}+x_{34} - 1 = 0,$
$g_4(x) = x_{41} - 1 = 0,$
$g_5(x) = x_{51} - 1 = 0,$
$g_6(x) = x_{62}+x_{63} - 1 = 0,$
$g_7(x) = x_{72}+x_{73} - 1 = 0,$
$g_8(x) = x_{82}+x_{86} - 1 = 0,$
$g_9(x) = x_{92}+x_{96} - 1 = 0,$
$g_{10}(x) = x_{10,2}+x_{10,4} - 1 = 0,$
$g_{11}(x) = x_{11,3}+x_{11,5}+x_{11,6} - 1 = 0,$
$g_{12}(x) = x_{12,3}+x_{12,5}+x_{12,6} - 1 = 0,$
$g_{13}(x) = x_{13,3}+x_{13,5}+x_{13,6} - 1 = 0,$
$g_{14}(x) = x_{14,3}+x_{14,5}+x_{14,6} - 1 = 0,$
$g_{15}(x) = x_{15,3}+x_{15,5} - 1 = 0,$
$g_{16}(x) = x_{11}+x_{21}+x_{31} + y_1 - \frac{15}{2} = 0,$
$g_{17}(x) = x_{11}+x_{21}+x_{31} - y_2 - \frac{3}{2} = 0,$
$g_{18}(x) = 3(x_{12}+x_{22}+x_{32})+ 4(x_{62}+x_{72})+ 6(x_{82}+x_{92})+4\,x_{10,2} + y_3 - 25=0,$
$g_{19}(x) = 3(x_{12}+x_{22}+x_{32})+ 4(x_{62}+x_{72})+ 6(x_{82}+x_{92})+4\,x_{10,2} - y_4 - 8=0,$
$g_{20}(x) = x_{63}+x_{73}+x_{11,3}+ x_{12,3}+x_{13,3}+x_{14,3}+x_{15,3} + y_5 - 5= 0,$
$g_{21}(x) = x_{63}+x_{73}+x_{11,3}+ x_{12,3}+x_{13,3}+x_{14,3}+x_{15,3} - y_6 - 2= 0,$
$g_{22}(x) = 3(x_{14}+x_{24}+x_{34}) +4x_{10,4} + y_7 - 6= 0,$
$g_{23}(x) = 3(x_{14}+x_{24}+x_{34}) +4x_{10,4} - y_8 = 0,$
$g_{24}(x) = x_{11,5}+x_{12,5}+ x_{13,5}+x_{14,5}+x_{15,5} + y_9 - \frac{15}{4} = 0,$
$g_{25}(x) = x_{11,5}+x_{12,5}+ x_{13,5}+x_{14,5}+x_{15,5} - y_{10} - \frac{3}{4} = 0,$
$g_{26}(x) = 6(x_{86}+x_{96})+4(x_{11,6}+ x_{12,6}+x_{13,6}+x_{14,6}) + y_{11} - 20 = 0,$
$g_{27}(x) = 6(x_{86}+x_{96})+4(x_{11,6}+ x_{12,6}+x_{13,6}+x_{14,6}) - y_{12} - 8 = 0.$
$g_{28}(x) = \sum_{i=1}^{15}\sum_{j=1}^{6}(x_{ij} - x_{ij}^{2}) = 0,$

The minimization problem at each iteration is solved here by using the package LINGO 17.0. The final results are given in tables 6 and 7.

Table 6: Computational result

Objectives	f_1	f_2	f_3	f_4	f_5
Optimal values	2.000	1.826	1.000	0.000	2.000
Objectives	f_6	f_7	f_8	f_9	f_{10}
Optimal values	0.667	1.404	4023	22	4.6

Table 7: Assignment according to preference level

Variable	Optimum Value	Corresponding assignment
X_{31}	1	3rd course, 1st faculty
X_{41}	1	4th course, 1st faculty
X_{51}	1	5th course, 1st faculty
X_{12}	1	1st course, 2nd faculty
X_{62}	1	6th course, 2nd faculty
X_{82}	1	8th course, 2nd faculty
X_{92}	1	9th course, 2nd faculty
$X_{10,2}$	1	10th course, 2nd faculty
X_{73}	1	7th course, 3rd faculty
$X_{11,3}$	1	11th course, 3rd faculty
X_{24}	1	2nd course, 4th faculty
$X_{15,5}$	1	15th course, 5th faculty
$X_{12,6}$	1	12th course, 6th faculty
$X_{13,6}$	1	13th course, 6th faculty
$X_{14,6}$	1	14th course, 6th faculty

General form of the multi-objective mathematical model of the faculty course assignment problem: To simplify notation, we denote the objective functions as follows:

$f_i(x) = L_i(x),\ i = 1, 2, 3, \dots, 6,$

$f_7(x) = A_1(x)$, $f_8(x) = A_2(x)$, $f_9(x) = A_3(x)$, $f_{10}(x) = A_4(x)$;
where $L_i(x)$, i = 1, 2, 3, …, 6, $A_1(x)$, $A_2(x)$, $A_3(x)$ and $A_4(x)$ are defined by (3.1), (3.2), (3.3), (3.4) and (3.5) respectively.

Finally, objective function is the following expression whose minimization gives us the desired solution:

$$f(x) = \sum_{i=1}^{10} w_i f_i(x) + \alpha \sum_{i=1}^{10} |f_i(x)| \qquad (3.8)$$

Here w_i and α are chosen value such that $0 < \alpha < \min(w_i)$

Table 8: Weight (w_i) values taken randomly to get optimum value of objective function.

Objective	w_1	w_2	w_3	w_4	w_5
Weight (w_i)	0.08	0.02	0.03	0.08	0.08
Objective	w_6	w_7	w_8	w_9	w_{10}
Weight (w_i)	0.06	0.17	0.21	0.10	0.17

Objective function value of *f* for equation (3.8) is 8.966 for $\alpha = 0.0001$, other objective function value is shown in table 9 and the courses assign is shown in table 10.

Table 9: Final computational results after weight function:

Objectives	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}
Optimum values	2	2.9	3	3	2	1.4	2.42	21	27	2.8

Table 10: Final assignments and preference level for $\alpha = 0.0001$.

Variable	Optimum Value	Corresponding assignment
X_{21}	1	2nd course, 1st faculty
X_{41}	1	4th course, 1st faculty
X_{51}	1	5th course, 1st faculty
X_{12}	1	1st course, 2nd faculty
X_{32}	1	3rd course, 2nd faculty
X_{62}	1	6th course, 2nd faculty
X_{72}	1	7th course, 2nd faculty
X_{82}	1	8th course, 2nd faculty
$X_{11,3}$	1	11th course, 3rd faculty
$X_{12,3}$	1	12th course, 3rd faculty
$X_{10,4}$	1	10th course, 4th faculty
$X_{14,5}$	1	14th course, 5th faculty
$X_{15,5}$	1	15th course, 5th faculty
$X_{9,6}$	1	9th course, 6th faculty
$X_{13,6}$	1	13th course, 6th faculty

Also, we have taken different α level to minimize objectives so administrators can select best faculty-course assign and results are as shown in below table 11 and table 12.

Table 11: Different $\alpha -$ level to get objective values:

α	f1	f2	f3	f4	f5
0.003	2.000	2.900	3.500	3.000	2.000
0.007	2.857	2.900	2.500	3.000	2.000
0.011	2.857	2.857	3.500	3.000	2.000
0.015	2.000	2.900	2.500	3.000	2.000
0.019	2.857	2.900	2.500	3.000	2.000
α	f6	f7	f8	f9	f10
0.003	0.600	2.351	24.000	27.000	4.000
0.007	0.600	2.316	24.000	27.000	4.000
0.011	0.750	2.246	25.000	27.000	4.100
0.015	0.600	2.211	24.000	27.000	4.200
0.019	0.600	2.316	24.000	27.000	4.000

For α = 0.003, 0.007, 0.011, 0.015 and 0.019 we get objective value of *f(x)* as 9.793, 10.163, 10.671, 10.615 and 11.020 respectively.

Table 12: Final assignments and preference level for different $\alpha - \text{level}$

$\alpha =$ 0.003	$\alpha =$ 0.007	$\alpha =$ 0.011	$\alpha =$ 0.015	$\alpha =$ 0.017	Optimum Value
X_{21}	X_{11}	X_{11}	X_{21}	X_{11}	1
X_{41}	X_{41}	X_{41}	X_{41}	X_{41}	1
X_{51}	X_{51}	X_{51}	X_{51}	X_{51}	1
X_{12}	X_{22}	X_{22}	X_{12}	X_{22}	1
X_{32}	X_{32}	X_{32}	X_{32}	X_{32}	1
X_{62}	X_{62}	X_{62}	X_{62}	X_{62}	1
X_{72}	X_{72}	X_{72}	X_{72}	X_{72}	1
X_{82}	X_{82}	$X_{12,3}$	X_{82}	X_{82}	1
$X_{12,3}$	$X_{11,3}$	$X_{13,3}$	$X_{11,3}$	$X_{11,3}$	1
$X_{13,3}$	$X_{13,3}$	$X_{10,4}$	$X_{13,3}$	$X_{13,3}$	1
$X_{10,4}$	$X_{10,4}$	$X_{14,5}$	$X_{10,4}$	$X_{10,4}$	1
$X_{14,5}$	$X_{14,5}$	$X_{15,5}$	$X_{14,5}$	$X_{14,5}$	1
$X_{15,5}$	$X_{15,5}$	$X_{8,6}$	$X_{15,5}$	$X_{15,5}$	1
$X_{9,6}$	$X_{9,6}$	$X_{9,6}$	$X_{9,6}$	$X_{9,6}$	1
$X_{11,6}$	$X_{12,6}$	$X_{11,6}$	$X_{12,6}$	$X_{12,6}$	1

V. DISCUSSION

The tenured ones are faculty who have less than three years work experience, whereas recent have more than five years' experience of teaching courses. These priorities are used in a conic scalarization method for combining different and conflicting objectives and the scalarized problems are solved by LINGO 17.0. The administration requests them to teach more hours than the tenured ones. In Tables 1, 2 and 3, A1, A2 and A4 refer to the faculty total preference level of faculty–course assignments, administration's total preference level and result analysis on courses respectively. A1 is obtained as 2.421, A2 is obtained as 21 and A4 is obtained as 2.8 for α value 0.0001. The total deviation from the upper load limits of the instructors (A3) is obtained as 27 for all solutions. The faculty and administrator preference levels for assigning courses are almost same for the any faculty for different values of α. The 1st, 4th and 5th faculty are tenured ones whose load are less comparing to recent faculty 2nd, 3rd and 6th faculty, so they have higher priorities (weights) in the assignment process than the recent ones. Preference of assigning courses to all faculty are almost satisfied. The 4th faculty does not get the preference base course as shown in table 6. But after weight function faculty 4th is also getting preference base, assigning as shown in table 9 as well as table 11 and table 12. More over A2 obtained without weight function was 4023 in table 6 is also minimize at 21 as shown in table 9. Each faculty has got courses, assigning according to administrator result preferences. Graph 1 shows optimum value of objective function for different $\alpha - \text{level}$. It is clearly seen that objective function value increase as $\alpha - \text{level}$ increases.

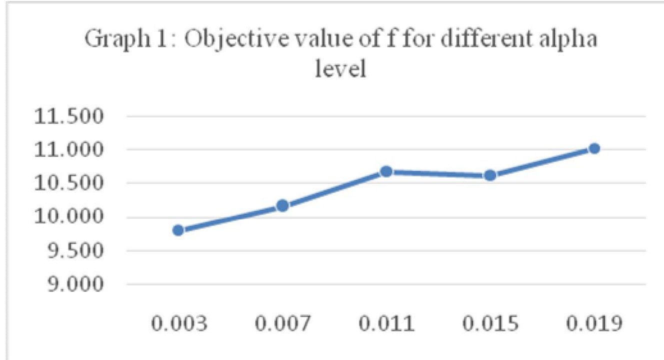
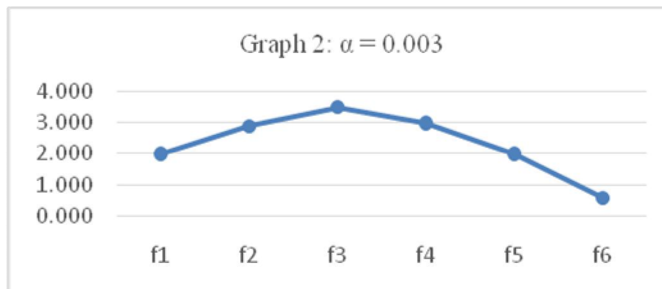
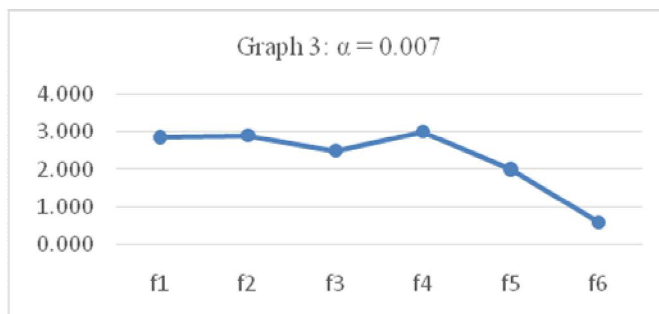
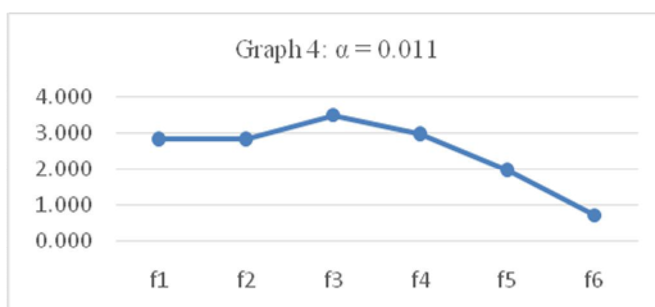


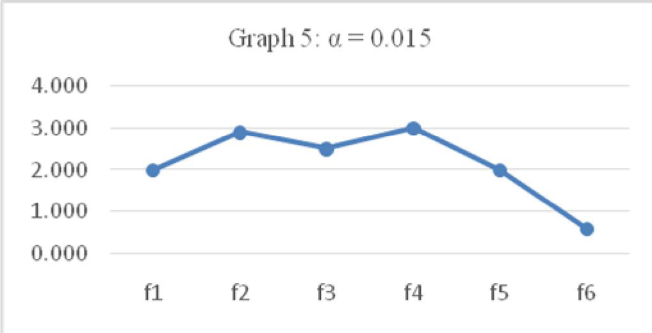
Figure 2: Graphs of different α level and objective functions.

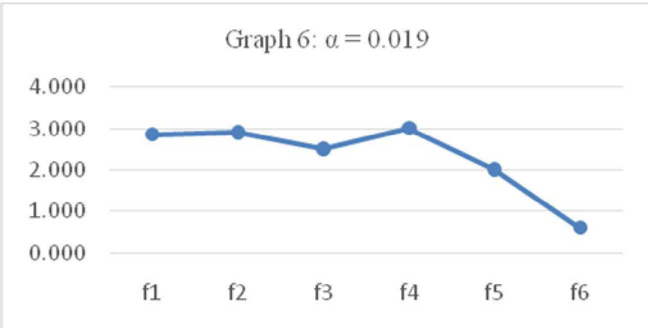
As $\alpha - \text{level}$ changes, there is minor change for f1, f2, f3, f4, f5 and f6 are shown infollowingsgraphs.











VI. CONCLUSION

Considering the pedagogical aspects of such assignments is an important contribution to the performance of an educational system. This study can be considered as an important stage in the complete solution of the classical course scheduling problem. By using the outcomes of this problem, more general timetabling problems in educational institutions can be solved more effectively. The final result was assigned to the faculty at the department of mathematics, UTU.

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